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ABSTRACT

Professionalism in the management and operations of the physical plant at universities and colleges is addressed in the 30 papers published in this Proceedings, which contains all the presentations made at the 1983 meeting. Papers and authors include the following: "Evaluation of Single-Ply Roof Systems" (Mark D. Langford, Steve Wolff); "Managing Maintenance Information" (Pieter J. van der Have); "An Effective Institutional Energy Strategy" (John R. Swistock); "Administration and Inspection of Contracted Custodial Services" (Robert Hutson, Ron Parker, Ralph Howitt); "How Our Energy Management System Changed the Way We Run Our Physical Plant" (Paul F. Barrett); "Energy Conservation from Waste-Cogeneration Potential" (Richard B. Robertson); "New Features of Campus Automation Systems" (Gregory A. Bruns); "How To Pick a Maintenance Management System" (C. K. Gold); "Developing an Engineered Plan for Managers" (Michael F. Baber); "Performance Review--A Motivational and Evaluative Tool" (William A. Custer); "Phased Approach to a Central Chiller Facility" (Peter J. Basso); and "The Six-Two Plan: Custodial Management at the University of Colorado" (John Madsen). (SW)

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Proceedings of

The Seventieth Annual Meeting of The Association of Physical Plant Administrators of Universities and Colleges

Setting the Pace for Professionalism

Vice President for Educational Programs:
Herbert I. Collier

July 10–13, 1983 Louisville, Kentucky

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Introduction

The Proceedings of the Seventieth Annual Meeting of the Association of Physical Plant Administrators of Universities and Colleges contains 30 papers presented at the meeting in Louisville, Kentucky, July 10-13, 1983. Readers desiring more information on individual papers should contact the authors.

Every presentation made at this year's annual meeting is included in the 1983 Proceedings. This year, for the third year in a row, we requested that the speakers submit camera-ready papers. All 36 authors/speakers (some papers were co-authored) complied with our request, thus making our job much easier and saving APPA more than $1,000. Another added benefit is that the Proceedings is ready two months ahead of the usual production schedule.

One copy of these Proceedings is being mailed to the representative of each APPA member institution, and to Affiliate and Subscribing members as well. Others who were official registrants at the meeting may also receive a copy upon request as long as the limited supply lasts. Additional copies may be purchased from APPA for $15 each to APPA members, $21 to nonmembers, prepaid (includes postage and handling).

Production of the 1983 Proceedings was coordinated by Steve Howard.

Paul T. Knapp
Executive Director
September 1983

In Appreciation

APPA would like to thank the following individuals representing APPA member institutions for their contributions to the success of the 70th Annual Meeting.

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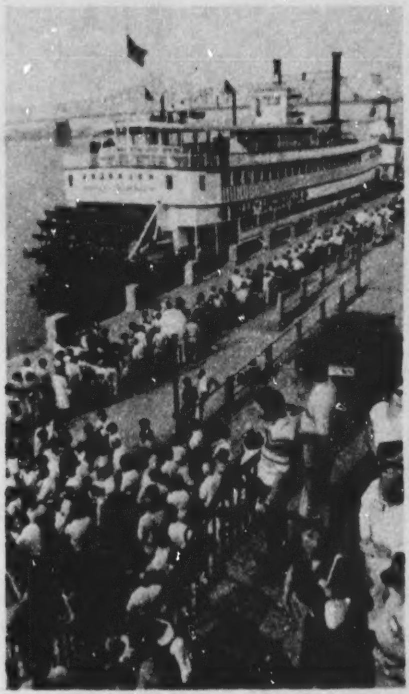
Photo Highlights of the Annual Meeting

Members and spouses line up for a dinner cruise on the Belle of Louisville.



Harold Babcock passes the gavel to Charles Braswell, APPA President for 1983-84.

Members discuss mutual topics of concern between educational sessions.

Ed Feldman speaks on Getting Through to People in his highlight presentation.

APPA staff members enjoy a moment at the annual banquet Tuesday night.

Phil and Winnie Rector celebrated their 25th wedding anniversary in Louisville.

Monday, July 11

LOUISVILLE, KENTUCKY

APPA '83

Professionalism in Managing and Operating Higher Education Facilities

By H. E. Bovay, Jr., Chairman of the Board, Bovay Engineers, Inc.

It's a pleasure and an honor to make the keynote address to this select group of higher education plant administrators at a meeting dedicated to setting the pace for professionalism. Your thoughts of professionalism, as it applies to the management and operations of the physical plant at universities and colleges, and the dependence of so many on you, is indeed important and I congratulate you on having wisely chosen professionalism of the highest order to provide much needed leadership in resolving the deep-seated complex problems currently besetting universities and colleges.

Meeting discussions here will probably center on the main functions of the physical plant to serve the colleges and universities on their total efforts and accomplishments. These would include (1) Operations, (2) Maintenance management, (3) Planning, design and construction, (4) Personnel services, and (5) Budgeting and cost accounting. My talk will be on professionalism as it applies to the management and operations of the physical plant.

In preparing this speech, Herb Collier was kind enough to give me a copy of your new manual for the Association of Physical Plant Administrators. I really believe many of you gentlemen could teach me a great deal about professionalism. Your manual is well done and helpful.

Let me begin by sharing my concept of professionalism. To me professionalism is a workable, useable, life-long career principle...an attitude and stature that should be part of each engineer's daily routine. It's not just a fancy word someone dreamed up. It's practical, because it makes a good engineer and good engineering even better. Professionalism is moral conviction--a sense of responsibility. It's the talent of being able to look at engineering problems with a broad perspective--to see all sides of a problem--human and social as well as technical and financial.

Professionalism is a plus factor that works in tandem with technology. It is that something extra...that positive force that insists on the full measure of excellence. It's the inspiration in your heart that's often planted there by your father, mother, uncle, professor, high school teacher, or scoutmaster. It's what Theodore Roosevelt meant when he said - There are two kinds of success. One is the very rare kind that comes to the man who has the power to do what no one else has the power to do. That is genius. But the average man who wins what we call success is not a genius. He is a man who has merely the ordinary qualities that he shares with his fellows, but who has developed those ordinary qualities to a more than ordinary degree.

The old quote by Herbert Hoover about engineering - and I think it applies to all of the members of APPA - has held up quite well with the passing of time. He said - It is a great profession. There is the fascination of watching a figment of the imagination emerge through the aid of science to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings jobs and homes to men. Then it elevates the standards of living and adds to the comforts of life. That is the engineer's high privilege ....The great liability of the engineer compared to men of other professions is that his works are out in the open where all can see them. His acts, step by step are in hard substance. He cannot bury his mistakes in the grave like the doctors. He cannot argue them into thin air or blame the judge like the lawyers. He cannot, like the architect, cover his failures with trees and vines. He cannot, like the politician, screen his shortcomings by blaming his opponents and hope that people will forget. The engineer simply cannot deny that he did it. If his works do not work, he is damned...The engineer performs many public functions from which he gets only philosophical satisfactions. Most people do not know it, but he is an economic and social force. Every time he discovers a new application of science, thereby creating a new industry, providing new jobs, adding to the standards of living, he also disturbs everything that is. New laws and regulations have to be made and new sorts of wickedness curbed. He is also the person who really corrects monopolies and redistributes national wealth. Of course, I am also including you gentlemen and ladies who are architects, or who have reached your present positions with other backgrounds. All of you now are professional administrators and so these thoughts apply.

One of my favorite descriptions of professionalism comes from a book written 34 years ago, "A Professional Guide for Junior Engineers" by William E. Wickenden in his chapter titled "The Second Mile":

> Every calling has its mile of compulsion: Its round of tasks and duties, its prescribed man-to-man relationships, which one must traverse daily if he is to survive. Beyond that is the mile of voluntary effort where men strive for special excellence, seek self-expression more than material gain, and give that unrequited margin of service to the common good which invests work with a wide and enduring significance. The best fun of life and most of its durable satisfactions lie in this second mile, and it is only here that a calling can attain the dignity and distinction of a profession.

I have found this to be particularly true in my experience. A practicing engineer deals with real people and problems rather than theory, so professionalism is frequently put to the test. Real challenges like the design for a mining operation, a fresh water treatment plant, an electric power generating unit, or plans to beam back solar energy from orbiting space stations are tangible needs. For instance, over 30 years ago some innovative engineering thinking made my firm a leader in the design of central energy plants for high-rise office buildings. It was a concept years ahead of its time, because it was highly energy conservative when energy was still plentiful and relatively cheap. There was no existing demand for that type of project in those days, but our engineers understood energy efficiencies and convinced client after client of the savings to be gained by filling their utility requirements from one central plant. On several jobs, clients were even able to supply the utility needs of neighboring buildings at a fraction of the cost of public utilities.

We found the university campus a natural application. Almost every campus can effectively use centralized power generation, centralized heating and, especially, centralized air conditioning. We have excellent examples to substantiate the wisdom of choosing the recommended systems-operation and the resulting satisfaction of continuing resultant benefits in cost and efficiency.

I believe each of us is well aware of the boom and bust events during the past three decades which have brought about the situations in our economy. Increased technological complexity of facilities and changes required for compliance with many government safety regulations didn't help, but basically a heavy contributing factor was allowing consideration of operating efficiency to carry such a low profile in the design of buildings and management of plants during the era of low energy, operating and maintenance costs. The drastic increases in energy costs following the 1973 crisis suddenly emphasized the importance of this neglect and the overwhelming odds against a quick fix. Dwindling resources compounded the situation as the physical plant departments often suffered the greatest fund reductions.

Eventually, administrators have come to realize that higher education is facing a future filled with problems which can only be solved through the highest order of professionalism. Furthermore, in order to achieve more economical operations, more comprehensive facilities planning, and close integration with academic and fiscal planning, it is imperative that the responsibilities for all facilities management functions be centralized under one chief administrator. Placed on a par with other top administrators he can greatly assist in institutional planning for the most effective utilization of physical resources, and for the most economical use of facilities funds in support of the institutions mission. He is in excellent position to achieve substantial cost reductions while handsomely improving reliability and efficiency of operation, as for example, a recent energy conservation project completed for East Texas State University.

This state university of approximately 12,000 students has 100 buildings constructed over the period of 90 years and served by almost every type of lighting and HVAC system marketed and in many cases old enough to be potential maintenance headaches.

Initially, the study involved 24 buildings which used over 85 percent of the university's total energy expenditure. The scope of work included a survey of mechanical and electrical systems and recommendations for modifications to energy usage and maintenance requirements. The survey identified many needs in each of the categories examined, which included (1) energy management control system, (2) reduced utility cost through limiting demand, (3) electric lighting relamping, (4) utility distribution, (5) building mechanical system energy reduction, (6) control settings and outside air balance, (7) architectural recommendations, and (8) remodeling of mechanical systems.

The summary showed that an investment of $3 million would be amortized in less than five years of operation. This did not include additional benefits occurring from the adoption of non-technical minimum investment items which with university and community cooperation would substantially reduce energy consumption, such as, (1) scheduling night or Saturday classes into certain buildings, and locking up the others at the end of afternoon classes, (2) changing holiday schedules to take advantage of reduced HVAC demands, (3) centralizing sensitive scientific equipment requiring special environments, and (4) several others. Many universities and colleges are in similar circumstances and needing relief. The challenges are real and significant. Professional ingenuity, creativity, expertise and persistence can help achieve these objectives.

These challenges not only exist on your own campus or in your own area, but in your state and in your federal governments. As professionals we must also help with the legislature and with the public. When we are talking to people who are not familiar with the university but who can have an effect upon the planning, or the budget, or the administration, we must always remind ourselves that people don't know what they want until they see what they can have. How can we instill in them the fact that our management requires quality, that anything less than zero defects in our approach is not for the good of the university or of the people who depend on it so heavily? The fact that we have this strong professional attitude and the fact that we are willing to reach out beyond our own offices to help other people in administration, to help state and federal legislators and bureaus, will probably have as big an impact on our ability to serve the needs of our university as anything else we do. While we are busy progressing with these present improvements, we must be flexible and be prepared to provide needs for the future. To many who tenaciously hang on to the industrialism of the past the future may look bleak and foreboding, but one need only raise sights to see the adventurous new technologies - electronics, biotechnology, alternative energy resources, mining of sea beds, robotics, and more - awaiting us to explore. As a born optimist, I am stimulated by this statement, laced with hope and promise, in the annual report of the Southwest Research Institute:

> For the future there will be no slowing in progress. Indeed there is reason to believe that imbedded in the current recession are the seeds of structural changes in our economy and society brought about by new technical advances helping industry and government to adapt to and exploit such new directions as those based on micro-electronics, semi-intelligent machines, and the remarkable thrust forward in biology and medicine.

In his recent book, Megatrends, John Naisbitt expresses the belief, as do other prominent social forecasters as Peter Drucker and Daniel Bell, that the United States is not decaying economically but is in the process of changing from an industrial economy, in which field we have lost supremacy, to a new information economy in which we are in a position to play the key role as innovator for the world. Estimates are that now over 60 percent of all employees work on the production and distribution of information, compared to only 13 percent involved in manufacturing operations. We have more people employed in universities than in agriculture, and are creating 600,000 new companies a year, over six times the 1950 total - not a static society as industrial decline implies. Naisbitt argues that it makes no sense to reindustrialize an economy no longer based on industry but on the production and distribution of information. Japan has displaced us as the leading industrial power which supremacy we cannot regain because dominance in the steel, autos, railroad equipment, machinery, appliances, textile, shoes and apparel is gone forever.

This restructuring will be as profound as was the shift from an agricultural society to an industrial society, with one important difference. It will only take two decades instead of 100 years. We do not have time to react and must anticipate the future.

As we look forward, we must help the educators and the public to understand that:

- Technical progress will be dominated by developments in microprocessors and genetic engineering.
- In ten years, the electronics industry will probably be bigger than steel and auto industries today.
- Information will be more important - we must learn to sort it and make it useful - not drown in it.
- Planes, satellites and space vehicles will shrink the world to where nations and cities and their economies and successes have greater dependence on each other.
- Computers will control production lines, accumulate and store information, and even replace some middle managers since top management will use computers for instant access to information.

These thoughts - and others we are becoming aware of mean that the challenges for engineers have never been greater, more demanding, more diversified, more complex than they are today. Nationally, and worldwide, engineers are being called on to solve literally thousands of problems in energy, environment, food production, transportation, mineral production, and more. In the daily contacts with professors, faculty members and others, you plant administrators and professional engineers and architects can point out these challenges and the constant need for change to help teach young people how to be prepared for the future.

I like to think of engineers' role in world affairs over the next 30 years as being similar to that of yeast in bread. Engineers will be the yeast--the inspiration--of civilization. They will be the leavening agent that makes life lighter, more palatable, and appealing. Without good engineers, existence will undoubtedly be hard, crusty, difficult to swallow, and perhaps bitter. But we have a serious shortage of them. I was dismayed to learn while attending an annual meeting of the National Academy of Engineering in Washington that in 1980 the United States graduated 56,000 engineers, while Japan, with half our population, graduated 73,000 or 17,000 more than we did. All major industrialized nations have relatively outperformed us in this most important area.

The engineering profession feels that industry, government and universities must work together on increasing the number of engineers and using them more effectively. Our industries must furnish higher salaries to them as an encouragement to get high school students into engineering, and our educational system must improve its product, especially in this developing literacy-intensive society when we need basic reading and writing skills more than ever before.

Higher education growth, both in size and complexity, will require expansion and reliability improvement, particularly on campuses with extensive technical training and research facilities. It is your important charge as professional administrators to see that higher education has a good physical plant to serve the increasing demands for longer hours in the universities, more studies, and a better climate for education to get us ready for the worldwide competition we are facing.

My visits with members of the APPA in the past and your kind attention convinces me all over again that you are one of the keys toward the survival of the universities, and for its very important impact in maintaining the United States world leadership. In fact, I think your own professional goals and thoughts and efforts put the Physical Plant Administrators very close to the university president. I'm sure you remember Clark Kerr's definition of The University President -

> The university president in the United States is expected to be a friend of the students; a colleague of the faculty; a good fellow with the alumni; a sound administrator with the trustees; a good speaker with the public; an astute bargainer with the foundations and the federal agencies; a politician with the state legislature; a friend of industry, labor, and agriculture; a persuasive diplomat with donors; a champion of education generally; a supporter of the professions (particularly law and medicine); a spokesman to the press.

Certainly many of you folks have to carry out many of these functions every day yourselves and in a year's time carry all of them out. And, also, like George Low, the President of Rensselaer Polytechnic Institute said, you understand relationships in your constant every day dealings with students, faculty, public contractors, designers, and all the people that you weld into one team for the forward progress of your university. I'm sure that you point out as George Low did that - There is no single right or wrong in these relationships. It is a time to experiment, to address problems when they arise, to be flexible in the details of their solution, and to do this without endangering the interests of either partner.

I know you will meet these challenges by developing and maintaining high standards in the administration, care, operation, planning and development of the physical plants. I know you will use your expertise, your innovativeness, your dedication and the extra effort required, unstintingly, while promoting professional ideals and standards that best serve the objectives of higher education.

Knowing What Makes Employees Tick: Using Type Theory as a Management Tool

By Phyllis Rossiter Forbes
Director, Administrative Services
University of New Hampshire

It is a pleasure to be here this morning and to share with you some of the insights I have gained in the application of type theory as a management tool. It is also a pleasure to represent what I hope will become a larger subgroup of your membership; namely, women managers.

Before I start, I want to state my basic position; I don't believe that people change unless they want to, and even then I am not sure that, in fact, they actually change. People *develop* and that development is in many ways predetermined. We are who we are and we try to change that at great risk to our sanity and emotional stability.

I also believe that people do not go into a job intending to perform poorly. Indeed, most people really want to perform well. In most cases, people perform poorly when; 1) expectations are unclear: 2) they are provided too little information to complete the task; 3) they are not provided the correct tools; 4) they need training in order to complete the task; 5) when they are a poor personality match with the demands of the job.

As managers, these beliefs ought to have special meaning. Basically, we have two choices: 1) we can adapt *jobs to people*; or 2) we can help people into jobs that better suit them (this may mean helping them out of the organization.) But we *cannot* change people to fit jobs!

As a manager, I spend a great deal of time counseling my people to look for other people or tools to support their weak sides, *or* to look for other work more congruent with their personality. While this may sound harsh, I believe it comes out of caring for people.

A leader is a leader only inasfar as others are willing to follow. The best laid plans are meaningless if we have no one to help us carry them out. As managers, achieving our goals depends as much upon how we handle our employees as it does paying them well. In fact, pay is often not the primary motivator for today's worker: self-satisfaction and appreciation from the person in charge and some sense of control over their jobs are often more important.

Type theory, which is based on the psychology of Carl Jung, is a powerful tool in understanding the dynamics of personality and how individuals respond differently to the same set of stimuli. The Myers-

Briggs Type Indicator is one of several instruments which can be used to determine personality types. As such, type theory and the MBTI, as it is called, can help us become better managers.

Comprised of four dimensions, the Myers-Briggs Indicator describes:

1. An individual's inner-or outer-directedness.
2. His/Her manner of perceiving, or collecting data.
3. The basis on which s/he makes judgments.
4. The extent to which s/he requires structure and closure in his/her life.

The instrument describes four basic styles and 16 different personality types. It is my intent today to describe the four dimensions of the MBTI; to give you some insight into how the various dimensions are expressed in behavior; to discuss how the four basic styles adapt to different working environments; and to share with you the results of administering the questionnaire to 42 maintenance workers at the University of New Hampshire.

The Myers-Briggs Type Indicator was developed by Kathleen Briggs and Isabel Briggs Myers (a mother-daughter team). It is based on Carl Jung's psychological theory and provides a framework for looking at how people deal with the world. One of the things the MBTI does is help us to value the differences in each other, as well as to understand them.

Jung saw two basic processes in life:

1. the perceptive process, or the way we take in information or collect data;
2. the judging process, or how we reach conclusions using the information we have gathered.

These two processes represent the core of the personality. In describing the MBTI, it should be remembered that no one dimension or style or type is better than any other. Each has its strengths and weaknesses. As I describe these dimensions, please keep in mind that I will be describing extremes in order to give you a sense of the opposite ends of the continuum. In reality, the interplay of the four functions changes each one subtly.

The first dimension of the personality is that of its direction, or where one finds one's energy. An extravert is a person who is oriented toward the outer world of things, people and action. These people are very social and tend to have a lot of friends and acquaintances. They are expansive, often tend to think out loud and find their source for approval to be in the external world.

Introverts, on the other hand, are oriented toward the inner world of ideas, concepts and thoughts. They are extremely inner-directed people, very territorial and prefer to have a limited number of intense relationships. They appear to be more self-sufficient than the extraverts because the source for their approval tends to be within themselves.

The second dimension is that of perception, or how one collects data or information. The senser gathers data through direct experience and deals in reality, facts and pieces of information. A senser wants empirical, practical data and they are likely to ask "what are the facts?". This type of individual learns specifics, which are then put together into a whole and much prefers to deal with practical applications rather than theory.

An intuitive, in contrast, gathers data through an indirect, unconcious process. This type of person deals in the meanings and relationships between objects and often goes beyond the five senses to gather information in large pieces which may be undifferentiated, at least initially. This type of person prefers to use hunches and inspiration rather than facts in moving toward the judging mode. An intuitive will not ask "what are the facts?". Rather, this individual will ask "what are the possibilities?" and prefers theory and abstraction to practical application.

The third dimension is that of the judging mode, or how one takes the information gathered and reaches a decision. A person who deals in the thinking dimension will make a decision through the use of logical, analytical processes. This individual is concerned to be objective and fair and is often viewed as being impersonal, cold and critical.

A person whose judging dimension is feeling, however, makes decisions through the use of value and relationship-oriented processes. This person wants to be subjective, is inclined to be persuasive and uses these types of arguments rather than those that stem from logic. In fact, logic is of very little interest or value to these people.

The final dimension is what is known as the world view, or how an individual deals with the outer world. Judgers like to plan ahead and to schedule their day, their week, their month. They strive for closure in most things and are apt to look toward making decisions in some way or another. They prefer a structured and organized life.

A perceiver, on the other hand, prefers to be tentative and to gather data long after a judger has reached a decision. Perceivers like to leave their options open and prefer dealing with flexible schedules and emergent possibilities. They are inclined to indulge in treasure hunting long past the time a judger would have made a decision.

I would like to state here that the Myers-Briggs Type Indicator places no greater value on one style or type than on any other. It is merely a descriptive tool to help us understand the differences in people, rather than a prescriptive tool which attributes goodness or badness to one style or type over another. I would also hasten to add that personality is dynamic and Jung felt that people continue to develop well into their fifties. The implications are that we may, in fact, change styles and/or types as we mature and our personality continues to develop. In no way is one's personality necessarily set in concrete when one reaches one's twenties. Indeed, much of the writing about the passages of the 30's, 40's and 50's would seem to support the assertions that Jung made more than half a century ago.

The core of the personality is the combination of the perceiving and judging modes (S-N, T-F). This core has a dominant function and an auxiliary function. The dominant function is the one function of those four which a person uses most often and most skillfully (either S-N, or T-F). The auxiliary function is the backup function. In other words, the dominant will be in one of the two pairs, and the auxiliary function will be in the other pair. The world view (J-P) will indicate which aspect of the core (S,N,T, or F) will be dominant and which auxiliary, although the orientation is different for introverts and extraverts.

Rather than confusing you with a technical description, I will only say that the extravert externalizes his/her dominant, for all the world to see, while the introvert internalizes his/her dominant, and externalizes the auxiliary, the weaker of the two functions. In other words, the world sees the extravert's strong suit. The introvert, on the other hand, internalizes the strong function and the result is that it is very easy to underestimate an introvert. This is a caution that all managers of people should think about carefully and continually.

The four basic dimensions, with their eight functions can produce 16 types and four different styles. Those styles are:

SJ: This individual is a stabilizer, a traditionalist and a maintainer whose quest is to belong and who prefers to be a part of an organized group.

SP: This individual prefers to be in the action at all times and functions particularly well as a trouble shooter or negotiator. Inaction and theory leave this type cold.

NF: This type is a catalyst and prefers to deal with people and human issues.

NT: This type is the visionary who prefers to create systems and whose chief desire is to do everything in the most competent way possible.

If leadership can be described as knowing how to appreciate the people we manage, it is important to understand that each style responds in a very different way to appreciation. The SJ prefers to be praised for his/her product orientation and for being responsible, loyal and industrious. They do not appreciate deadlines that are not met and people who do not employ standard operating procedures.

In contrast, the SP prefers to be praised for the manner in which s/he did the job, rather than the job itself. These people resent standard operating procedures. I don't have to tell you that having an SJ manage an SP (or vice versa) can create some real problems if one is not aware of the different orientation.

An NF prefers to be commended for being a unique person making a unique contribution. Especially important is to acknowledge their feelings as well as their ideas. They respond very poorly, if at all, to impersonal treatment.

Finally, NT's like to be appreciated for their ideas and capabilities. However, never let an NT be appreciated by someone s/he considers less competent. This is likely to bring out a streak of arrogance in the NT.

An NT also does not appreciate being thanked for a routine task well done, because NT's strive to do everything well. They are particularly offended by being asked to do something which is illogical or violates reason.

It is quite easy to see by the preceding description the potential for fireworks in any management situation if one has grouped together differing styles and types. I do not mean to suggest that one should look for people who are the same as oneself when hiring one's employees. Indeed, I would go as far as to say that most healthy organizations go out of their way to avoid cloning whenever possible. The best teams (whether management or workers) are comprised of complementary styles and types. If I were to create the ideal work team I would strive to have a sensing type who would establish the facts; an intuitive type who would suggest possible solutions; a thinking type who would determine the probable consequences of each course of action; and a feeling type who would weigh the desirability of each outcome in human terms. But I would do this recognizing that communication across types is difficult. In order to facilitate communication, we must define our terms so that all can understand them. A senser wants facts and an explicit statement of the problem before considering the solutions. An intuitive wants the prospect of an interesting possibility before they look at the facts. (Not for them a mundane solution!) A thinker wants a statement to have a beginning, be logically arranged and concise in the sequence of its points, and an end. A feeler wants to deal with problems or statements that affect people. Each type will tend to look for language that describes these differing orientations.

Without question, those of you who are intuitive thinkers (NTs) are probably enjoying this description of an abstract theory. Most of the rest of you are probably sitting here asking "Well, of what relevance is it to me in my job? I have to reduce my turnover, increase productivity and satisfaction and how does the MBTI help me?" I am happy to say that type theory can help you in a number of ways, some of which I would like to suggest now.

In the first place, one ought to look at the kinds of jobs into which one puts people and help them to decide what their preferred environment is. The extravert will prefer a job with a fair amount of action and a fair number of people with whom s/he must interact. Introverts, on the other hand, have a great need to work alone or with a few other individuals in quiet surroundings. Putting them on the front line in a situation where they are constantly having to deal with people may be exhausting for them and may essentially doom them to failure. Conversely, putting an extravert in a back room with very few people will probably result in a lot of trips to the lavatory or the water fountain in search of people.

The second area where the MBTI can be helpful is in trying to distinquish between people who like to deal with specifics and their practical applications as opposed to those people who prefer to deal with theories, generalities and complexities. The senser much prefers the former and the intuitive the latter. Intuitives make notoriously poor accountants, while sensers make notoriously poor long-range planners.

One ought also to look at whether or not a job requires an individual to work with objective, inanimate things or with people. Thinking types much prefer jobs that allow them to exercise their logic and their analytical thinking. Feeling types, on the other hand, prefer to exercise their persuasive abilities and to deal with people. To put the feeling type into a job where they have very little to do with people or have to spend a great deal of their time dealing solely with inanimate objects is to doom this type to failure. Thinking types, on the other hand, ought not be used to sell unpopular ideas or to be totally responsible for improving morale.

Finally, is the job in question one in which it is necessary to be organized, follow procedures and make decisions, or is it one where the individual can spend a great deal of time collecting data and essentially moving with the flow of events? A judger is much more content to be in the former type of job, while a perceiver prefers to be in the latter type. To be a judger in a situation which is constantly changing and in which there is very little predictability is to guarantee a high level of stress and/or job dissatisfaction. By the same token, a perceiver ought not to be placed in a job which is the same day in and day out.

In the course of writing this paper, I administered the MBTI to 42 maintenance workers at UNH. Almost the entire range of trades was represented, as well as a number of supervisors. It was my theory that sensing types would outnumber intuitives, which they did by a ratio of more than 10:1. This is not surprising, considering that the jobs require abilities that are primarily empirical, technical and practical. The surprise for me was that SJ's outnumbered SP's by a ratio of 4:1, suggesting that a definite product orientation exists on their crews. (This was a surprising outcome. I had expected the ratio to be reversed.) I overheard one SJ, a pipefitter, discussing a pipe that froze every winter because no one had yet done an adequate job of insulating it. This is typical of the product-oriented SJ. In expressing praise to these SJ's, any successful supervisor must remember to praise the product, while with the SP's, the successful supervisor will praise the flair with which the job is done. This is a crucial distinction.

Of five leadworkers/assistant foremen, three were SJ's, one an SP and one an NT. In observing these individuals, the SJ's lead by virtue of their organizational skills, and tend to lead larger teams, while the lone SP leads by example. SP's are, by nature, not organizers and the particular individual in question is successful because his shop is small and deals with a (relatively) small range of problems compared to the area maintenance teams. In fact, this individual requested a voluntary demotion several years age, after being promoted beyond his ability to organize and willingly acknowledges his inability in this area. The NT leads through his ability to conceptualize and to trust his men's capabilities.

The three intuitives in the total group are interesting individuals. One, a lead-worker, could not claim any one trade as his own (i.e. electrician, carpenter) and by the testimony of his men, he was capable of all. The other two intuitives stood out in their work groups as being different. One has a Master's degree in English Literature and the other has two years of engineering under his belt. Both are bored with detail and repetitive work and make no bones about it.

Some other observations are in order before I close my remarks. There were more extraverts than introverts, although less than might be expected in the population at large. This group has a significant number of introverts and the caution I expressed earlier needs to be reiterated. That is, observe your introverts carefully, lest you underestimate them. One does not see the introvert's strong suit, which is introverted; rather, one sees the auxiliary, or the back-up function. With the large number of introverts in this group, I would recommend that any supervisor take care in approaching them. This is not to suggest that extraverts are any less complex. Indeed, this is not so. But extraverts are, by definition, "right up front" and are easy to track. Not so the introvert.

Thinking types outnumber feeling types 2:1 and the delivery of praise and/or criticism ought to differ for these two groups. Thinkers prefer to have an impersonal standard applied, while feelers prefer a subjective, personal standard (if "standard" is the correct term, in the latter case).

Finally, judgers outnumber perceivers 3:1, meaning that the clear majority of this group prefers organization and closure. However, one ignores the perceivers' need to be flexible only at great risk. In the ideal world, all troubleshooters would be perceivers and all system maintainers would be judgers. The practical and successful supervisor tries, to the extent possible, to adapt jobs to the people doing them.

What I have tried to do in my discussion today is to illustrate how knowledge of the Myers-Briggs and of one's employees is invaluable to the manager who wishes to inspire his/her workers rather than just managing by fiat. Awareness of one's own style and type, and how it is perceived by others, as well as knowledge of the four basic styles in those supervised, allows the manager to tailor his/her leadership to the personalities of those working for him/her. Whether we like it or not, our employees can make or break us as effective managers and leaders, and understanding the orientation from which they are operating allows us to appeal to their strengths rather than their weaknesses.

Carlson

Conversion From Constant to Variable Air Volume System

By Donald A. Carlson, College of DuPage
and Ken Yoshitani, Energy Management &
Engineering, Inc.

Introduction

The College of DuPage is a two-year community college located in Glen Ellyn, Illinois. The student population is 24,000 (13,000 FTE). The College consists of several large classrooms/office buildings with a total floor space in excess of 700,000 sq. ft.

In the spring of 1980, the College of DuPage authorized Energy Management & Engineering, Inc. (EME) to conduct an energy conservation study. The study was conducted in accordance with the requirements of the Institutional Conservation Grant Program. The study, therefore, investigated a multitude of energy conservation opportunities, and the proposal to modify the existing constant air volume terminal reheat system to a variable air volume system was one of the nearly one hundred energy conservation opportunities evaluated. This modification was scheduled for Building "A" which is a multistory classroom/office building with a floor space of approximately 404,000 sq. ft. The building was designed in 1968, and a terminal reheat system was installed. At the time the College began to occupy the facility in 1973, it became apparent that the cost of operation of the terminal reheat system would be prohibitive, and, therefore, the system has been operating primarily either in a heating mode or a cooling mode.

The Building HVAC System consisted of eight constant air volume reheat systems with a total supply air flow of 580,000 cfm and a total supply and return fan horse power of 1,053 H.P. The College experienced problems with this system from 1973 till the present time in attempting to operate it. The system never gave satisfactory heating and cooling in many of the areas of the school, and the temperature, whether it be winter or summer, was very erratic. The engineering staff attempted to remedy this problem by using the terminal reheat boxes, the baseboard, and the air distribution system, however, a satisfactory balance could never be obtained. Also, the system, although balanced twice by outside contractors, was never acceptable as far as College personnel were concerned.

Design Development

The design development stage of the project started in January of 1981. The school administration met with representatives of Energy Management & Engineering (EME) to begin the initial phase of design. During this phase of the project the initial design criteria for Building "A" was established, and how the modifications which had already been instituted in the building would affect the criteria, and, therefore, would affect the overall design.

During the initial phase of engineering certain design limitations were explicitly defined. These were:

1. Major duct work modifications will not be undertaken. This limitation was due to the fact that the building would be occupied during the whole installation process. Therefore, we could not disrupt the every day activities of the building by tearing out large duct work and redesigning it to better meet our needs.

2. Fans will not be removed due to the configuration of the building. It would have been impossible to get the existing fans out of the four fan rooms and new fans put into this area without tearing out large sections of existing wall.

3. The third limitation was the existing control system must interface with the new system, and also, a future building automation system which would be designed to meet the changing needs of the campus. The existing control system was Honeywell Delta 2000 which had performed satisfactory for eight years. However, due to technological advances in this area, the College planned to install a new system within the next two years.

Once the study of the as-built drawings were completed and limitations were defined, EME undertook a detailed energy analysis of Building "A", using DOE 2.1 Energy Analysis Computer Program. The analysis incorporated the effects of the other energy conservation measures which were previously installed, such as: (1) additional wall insulation, (2) window shades, (3) lighting modifications, (4) loading dock modifications, and (5) heat reclaim equipment. The revised heating and cooling loads were used in the new design criteria. The information received back from this program indicated that the system was oversized. However, the modifications which had been completed to date had greatly reduced the need for the large volumes of air for heating and cooling, therefore, the existing HVAC system became grossly oversized for the application. The same information was fed through the Carrier E-20 Program, and the results received from this program were identical to that received from DOE 2.1. EME then began to develop the drawings and specifications which would be used to bid the project.

Scope of Project

The computer analysis and subsequent engineering revealed that fan downsizing of all eight systems would be possible. Because of the physical impossibility of changing out the fans, fan motors were downsized and fan speed controllers were recommended to be installed. In terms of gross horse power, reduction was approximately 60 percent. The installation called for sixteen (16) AC inverters to control the fans to the proper speed.

The next item on the modification was to change out the existing terminal reheat stations (445 of them) to pressure dependent variable air volume mixing boxes. In order to keep disruption to a minimum, it was decided to leave the terminal boxes intact and set the mixing boxes ahead of them, wherever possible.

The last item to be discussed in the scope of the project was the fan tracking control system. The specification called for the installation of an air monitor system which would track the fans and keep the return air fans working in conjunction with the supply fan. Although the scope of the project was spelled out in the specification, the bidders were given the opportunity to bid voluntary alternates. The voluntary alternates would be reviewed in the bid phase prior to awarding the contract.

Before the bids were issued, the specifications and the equipment which had been proposed were once again reviewed. It was found that both the construction cost and the payback to be underestimated. Both the College and EME felt that the current cost of the installation would be in the neighborhood of $550,000, and that this would give a payback of approximately 3.9 years. With this revised budget figure, the bids were issued to the contractors.

Bid Phase/Contract Award

After the final review of the bid documents by the College Administration and EME, the bids were let to twelve (12) local contracting firms. A pre-construction meeting was held, and the scope of the project was discussed. The contractors were given four weeks to review the specifications, visit the site, and present their sealed bids. At the bid opening, seven contractors submitted bids. The priced ranged from $400,000 to $1,200,000, with the majority of bids in the $400,000 to $650,000 range. The College Administration and EME began evaluations of the submittals. It became apparent that any bid above $650,000 would not be reviewed, as these proposals did not conform to the projected budget for the project.

After further reviewing the bids, it became apparent that the bids submitted by two of the contractors should be reviewed in detail. One of the contractors had submitted a base bid on the specification of $575,000. The other contractor had submitted a price on the base bid of $625,000. The second contractor had also submitted a voluntary alternate of $440,000. Upon reviewing these bids, it was found that the contractor that had submitted the price of $575,000 had omitted substantial demolition work which would be required. The contractor was asked to resubmit showing this demolition work, and the revised bid went up to $650,000. Then, the two bids submitted by the other contractor were reviewed, the base package and the voluntary alternate. In reviewing the voluntary alternate, it was found that his main savings was in recommending a Voltec Direct Digital Control System for fan control over the Air Monitor or Cambridge System. As neither EME nor the College were familiar with the Voltec System at this time, an extensive study to find the difference was undertaken. Cambridge and Air Monitor sites in the area, and Voltec installations in Pittsburgh were visited. Two other Voltec installations, one in California and and one in Texas, were also contacted. It was during this investigation that the Voltec Direct Digital Control System would meet the requirement, possibly better than the proposed Air Monitor or Cambridge type pneumatic system.

Further study showed that the contractor who had submitted this proposal had spent quite a lot of time studying the existing ceilings which are not of the standard size tile and figured a way to do the demolition with minimal damage to the existing ceilings. This also helped reduce his cost, and he was able to show a rather large savings in this area.

Another area in which the contractor showed savings was in proposing to use mechanical drives on fourteen (14) of the fans and the AC inverters on only two. The other contractor had proposed to use all AC inverters and did not propose the use of mechanical drives.

Having been in ventilation for twenty years prior to coming to the College, and being familiar with many of the contractors in the area, I contacted a contractor who had not bid on the job due to excessive work, and asked him how he would propose to do the job. It became apparent in these discussions that he would have proposed the voluntary alternate much in the same fashion as the successful bidder, using the Carnes boxes, the mechanical drives wherever possible, and the Voltec air flow monitoring system.

During this review process, the Reliance Factory in Columbus, Indiana was visited and observed the mechanical drives in operation. Also, General Electric was visited and the AC inverters in operation were observed. The Carnes Factory was also visited, and installations using the Carnes boxes which had been proposed, were also inspected. In all instances, very favorable observations were made.

The contract, based on the voluntary alternate, was awarded to Admiral Heating and Ventilating, Inc., of Hillside, Illinois, for the sum of $440,000, with work to begin in May of 1982.

Installation

A pre-construction meeting was held the first part of May, and the contractor submitted a schedule calling for work to begin on or about May 15 and ending November 25. The tasks identified in the work schedule were: (1) ceiling demolition and replacement, (2) VAV box installation, (3) thermostat installation, (4) fan drive installation, (5) fan monitoring and air flow stations, (6) electrical work, and (7) test and balance. Work began May 20 with the demolition of the ceilings in Building "A". This work consisted of removing ceiling tiles wherever possible and cutting access holes into the drywall ceilings in the remainder of the project.

This part of the project was for the installation of the Carnes boxes. A week after demolition began a crew began to install the Carnes air mixing boxes. As expected, a number of problems appeared in the early stages of construction. The first main problem was the space in the ceiling was not sufficient for proper installation of the mixing boxes. This resulted in the removing of many of the terminal reheat boxes which existed. As these terminal reheat boxes had not been used for many years, there was no concern with their removal, and therefore, allowed the contractor to proceed.

The second problem which became apparent in this part of the construction was the air flow sensing devices had to be installed in long straight sections of the duct. In some cases this was not possible due to the many turns in the ceiling, and there were not any sections that met the installation criteria. The contractor reported back to us on the areas that were the greatest concern, and in these areas he revamped the duct work to meet the criteria set up by the manufacturer of the air flow devices for proper installation.

Beginning the first part of July, the contractor began to install the fan drive assemblies on each of the fans. Once again, unseen problems began to arise. Due to the physical size of the fan drive units, they had to extend the bases to receive the new drives. This was accomplished with minimal problems to the contractor. However, another major problem arose, and that was that the weight of the new drives far exceeded the weight of the existing motors. They set isolation springs under all the fan units, as the new drives had caused existing springs to bottom out. One other problem occurred during this time which the College was aware of, although up till then there had not been any problems with it and had been watched very carefully, and that was that the original building and motor hook-ups had been wired with aluminum wire. The motor changing gave us a good opportunity to correct this problem, and so electrical contractor on the job pulled new copper wires to all the motor starting centers. The electrical contractor, at this time, was also beginning the control wiring for the Voltec panel back to the Chief Engineer's office.

During the summer at the College of DuPage, even though a summer program is offered, our student population is greatly decreased. Also, there is a five-week break between the Summer Quarter and the Fall Quarter during which time they had to accomplish the majority of the work in the building and also on the drive units. The contractor was allowed to shut down only one fan unit at a time because cooling had to be maintained in the building during the entire installation. When the contractor would complete one of the drive units, we would supply air to it and bring it up to 90 percent of its rated speed, and bring it back on line so that zone would begin to receive cooling while we worked in another area. They also staggered the areas so that we did not have two fans off in the same area consecutively.

All the work progressed on schedule so that by mid-August the majority of the boxes had been installed, and the majority of the drives were in place operating in a manual mode. In September, final control hook-ups to the Voltec panel and replacement of ceiling tile began in the building so that the system could be properly balanced in mid-October. Although work progressed relatively on schedule, other problems occurred which had not been reflected in any of our engineering studies, or the as-built drawings. One example, this was motorized dampers which were found on the third floor of the building. Although these dampers were put in place to restrict air flow to the third floor originally, they were no longer needed with the new installation, and they were disconnected and wired open. This was accomplished by climbing through the duct work and locating each of the dampers, locking into an open position, and disconnecting the motors.

One other problem which was discovered during this time was the existing fiber connections for duct isolation were found to be rotted and blown out in many locations. This was caused by the high pressure of the air which had been running in the previous system. Although this did not affect the overall operation of the old system, it created a very serious problem in the new system, as our minimum cfm was greatly reduced. All fiber connections which created problems were replaced during the first part of October.

One other point of interest on the project was that the College decided to build an 18,000 sq. ft. Bookstore in a light court in the middle of the building at the same time the retro-fit was being installed. The initial proposal for this Bookstore called for a separate fan unit to be set into the area. As the design came in for the Bookstore construction, the possibility of supplying air to the Bookstore off an existing fan system became feasible. Zone 5 was used to accomplish this. The initial specification had called for a 30 H.P. motor to supply Zone 5. This motor was increased to a 50 H.P., thereby, picking up enough air to supply the new Bookstore. The College saved $50,000 in the construction cost of the Bookstore due to the change.

In spite of these changes and problems, all the major components were installed by November 25, and the system was ready for start-up and testing.

Start-up

The start-up and testing was originally scheduled for two weeks. Actually, the start-up and testing lasted approximately six weeks. The problem was one of constructured scheduling coordination with the classroom schedule and with the availability of the key start-up and testing personnel.

There were problems encountered during this period which have since been corrected. The first problem which occurred was that approximately 5 percent of the 430 mixing boxes had problems with the opening and closing. While the percentage was not unusually high, the College undertook an ambitious program to recheck all the boxes installed. Since this time we have not had any reoccurring problems with these boxes.

The second problem was the operation of the air flow control system. The readings which were received back on the system monitoring devices did not correspond to what the system had been balanced at. The contractor brought in another balancer and went through the system again to verify the initial Balance Report. Many discrepancies were found in the first report. The engineers from Voltec were then called and verified their readings with the Balance Report, and took additional readings to verify that all control devices were giving the information which was needed to make this system operate efficiently. After this was completed, the air flow control system began to function smoothly.

The mechanical speed controllers which were supplied by Reliance had a number of minimal problems. However, Reliance responded quickly to make the necessary repairs and replace the defective parts. All mechanical speed controllers have been operating smoothly.

The two AC inverters which were supplied by General Electric have had recurring problems. To date these problems have not been isolated, although many different theories have been received from the engineers at General Electric. Although they are looking into them and trying to come up with a proper solution, the College is still not satisfied with their operation. Currently, they are changing out many of the electronic components. The College is hoping that this problem will be remedied by this change.

In any installation such as this, you expect problems in the start-up phase. It would be worth pointing out though that the system which was supplied by Voltec to control and synchronize the fans has performed very satisfactorily since the day it was turned on. Although there have been questions regarding its operation, Voltec has been very quick to respond with engineers sent to us from Pittsburgh and been very helpful in training our people to use the equipment properly. They have also changed the software twice at their cost, even though this was not required in the specifications. Both the engineering firm and the College are very satisfied with their decision to go with the electronic direct digital control, rather than the pneumatic type control such as we originally specified.

Changes in Operational Procedures

The College engineering staff began operating the system, although it was still being checked out in January of 1983. It became immediately apparent that their operational procedures would have to change. In the past the majority of heat had been supplied from the steam coils located in the air handlers and about 50 percent of the terminal reheat boxes. The outside perimeter heat had been used only on weekends and running at a minimal setting. With the new system in operation, it was found that the remaining terminal boxes to heat the building would not be needed. The building would be using only the steam coils in the air handlers and the perimeter baseboard system In January the supply water was 130 degrees through the perimeter system, and about 64 degree discharge air through the ventilation system was being delivered. Certain areas began overheating. The mode of operation was changed. We lowered our discharge air temperature to 57 degrees, and slowly increased the temperature of the water, depending on the outside temperature. Although the heating season was mild last year, there was a few days of zero degree weather. During this time our water hit the highest discharge temperature of the season, and that was 145 degrees. Our discharge air still remained at 57 degrees.

Under the old system there were many hot points and cold points in the building which the engineering staff could never seem to get control of. Under the new system with the different operating mode, the staff found that the building would be evenly tempered throughout, and all hot and cold spots had been eliminated. In one of the previous paragraphs it was mentioned that an 18,000 sq. ft. Bookstore was installed in an internal light court. This was being heated with the same 57 degree air. In addition there are six fan coil units on the third floor which circulate the water through to give additional heat in this area of the Bookstore to compensate for two 80 ft. skylights. These units are designed to come on when the building is unoccupied and the fans are set at a minimal discharge air cfm. The building had experienced some coolness on Monday mornings, however, this was quickly rectified and by 9 a.m. the building would be very comfortable. The engineering staff is still adjusting their operational mode to the new system. The College is also currently in the process of relocating outdoor reset controllers so that more accurate interior temperature can be maintained, as compared to outside temperature. It was found that this was necessary since the perimeter zone has become the primary source of heat to the building.

Currently, the system is in the cooling mode. Here again, the engineering staff have had to change their operational procedures. They start out on a Monday morning when the building is warm supplying 100 percent supply air and running a chilled water at about 46 degrees. As the building begins to cool down and the fans begin to slow up, the temperature of discharge water is slowly increased. In doing this, the staff can keep the fans running at a approximately 100 percent for circulation and take some of the load off the chillers. This operational mode is found to best fit the changing needs of the College, and as the people start to arrive for the evening classes, temperature is lowered. Chilled water is fluctuating from 46 to 50 degree discharge through the system and returning from at anywhere from a 6 to 10 degree differential, depending on the occupancy of the building and the outdoor temperature. The engineering staff are also very careful to keep our coils below dew point temperature so as to get maximum humidity removal during the summer mode.

The major problem that the College has experienced with the system is in the cooling cycle, and in that occasionally there are some cold spots in the building. A problem that the College has had in both the heating and the cooling is that the equipment is oversized to the extent that they cannot keep them on line. By operating the equipment with false load, the staff can keep them on line during periods of low demand. The engineering staff at the College has learned that they no longer just turn a valve when they receive a complaint, but they look at the air being sent to the area, the temperature of the water being sent to the area, the outside temperature at that time, the internal population of the building, and the anticipated temperature changes outside; then attempt to make their decisions based on all this information, rather than just responding to hot or cold complaints. The complaints from the staff have decreased this summer as compared to previous years. Although as mentioned earlier, there are still some cold areas in the mid-afternoon.

At this point our operation is still in the experimental stages. Procedures are being established for the existing facility. Beginning in the fall, an additional 400,000 sq. ft. will be added to the same boiler and chiller plant, and, therefore, historical data is needed to show how the added facilities will affect our overall plant operation.

At this time the other control mechanism that is being considered is a building pressurization software package which will be installed in the Voltec System. This package will give even closer control on air movement through the building, and not only reduce operational costs, but also help control comfort to the various areas in the building much more efficiently.

Each day with the changing weather conditions and the increase and decrease in building population, the engineering staff are making minor adjustments in the overall operation. As they are still in the trial stage, operational procedures have not been put in writing. This is not anticipated for at least three more months, at which time procedures will be developed for our own information in the existing building. As the other buildings come on line, they will be modified then to meet the changes.

One additional benefit the College has gained from the installation of this system is that the engineers have been forced to think through problems from all sides, prior to making a decision on the system operation. The College administration welcomes this added benefit, and feels that the engineers are better qualified in the overall building operation and able to deal with these improvements, as well as future changes which will take place in building automation.

Summary

The intent of the system modification from constant to variable air volume system was to reduce energy consumption. Table I lists KWHR used and associated total cost (includes demand and "other" charges such as taxes) for the two comparative periods. The noticeable reduction starts in November of 1982 when fan motor downsizings were initiated. (See attached tabulation of KWHR usage and costs). The projection of energy consumption reduction for a year is nearly 5,000,000 KWHR. At the current equivalent rate of approximately 6¢/KWHR, the annual savings is approximately $300,000 per year.

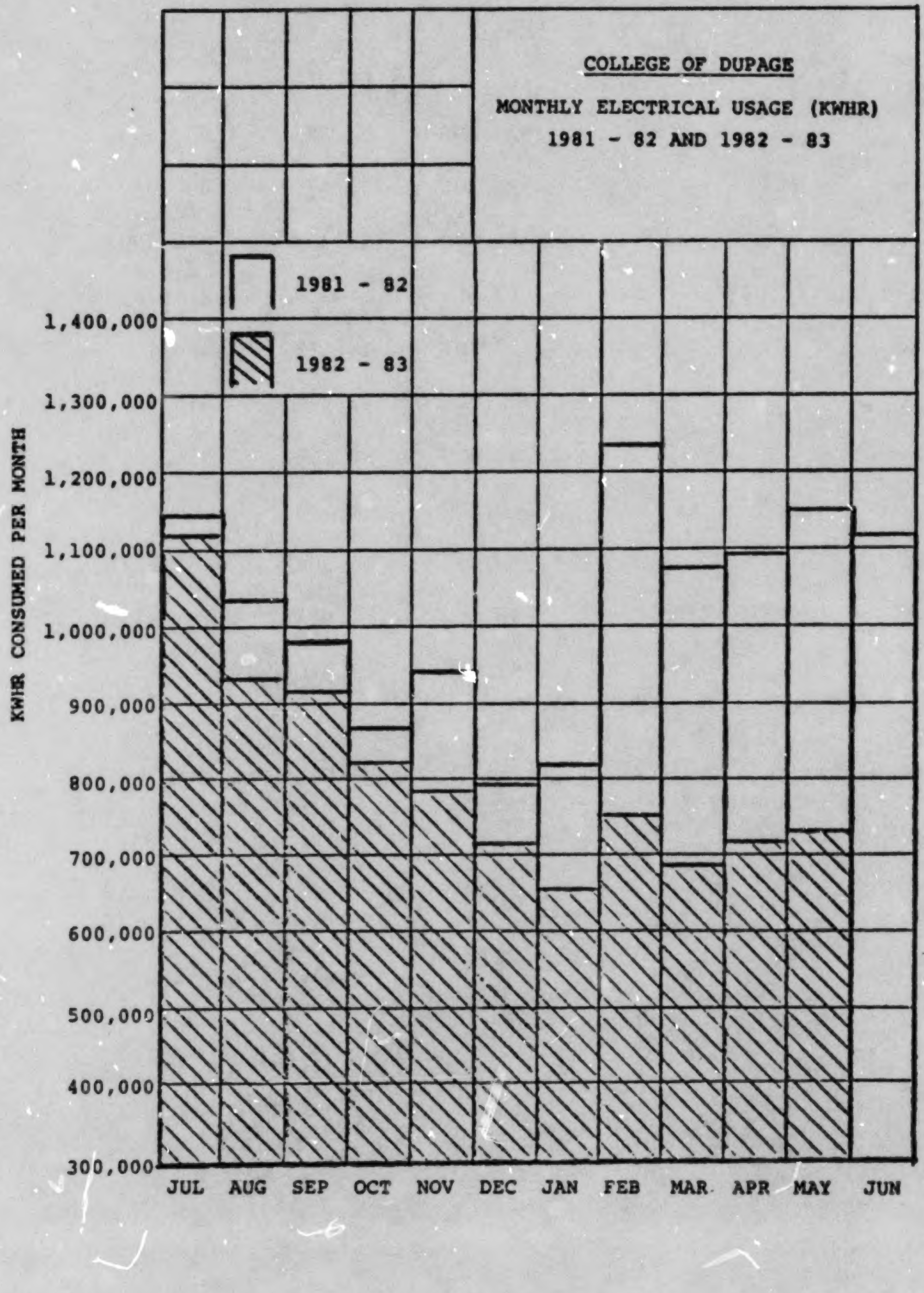
There are also other additional benefits which are not so obvious, gas usage has been reduced. Chilled water usage has been so reduced that the chiller is operating at low efficiency, and because air flow rate has been significantly reduced, filters need not be changed out as often.

Overall, the conversion from constant to variable air volume, although not without some problems, has shown to be a successful energy conservation project.

MONTHLY KWHR USE & TOTAL COST - BUILDING A

	1981 - 1982		1982 - 1983	
	KWHR	COST	KWHR	COST
July	1,106,400	$ 66,018	1,008,008	$73,715
August	924,000	58,526	1,029,600	75,132
September	931,200	57,399	900,000	63,487
October	854,400	49,931	844,800	57,004
November	912,000	51,929	775,200	45,505
December	787,200	46,413	686,400	39,061
January	784,800	47,284	645,600	41,197
February	1,221,600	69,142	744,000	45,900
March	1,060,800	61,473	633,600	42,970
April	1,070,400	64,994	668,122	42,230
May	1,149,600	74,931	682,350	45,150
June	1,080,000	77,414	--	--

NOTE: TOTAL COST INCLUDES ENERGY, DEMAND, AND OTHER CHARGES, INCLUDING TAXES.


COLLEGE OF DUPAGE
MONTHLY ELECTRICAL USAGE (KWHR)
1981 - 82 AND 1982 - 83
1981 - 82
1982 - 83
KWHR CONSUMED PER MONTH
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN

Langford

Evaluation of Single-Ply Roof Systems

by Mark D. Langford
University of Missouri
and Steve Wolff
Neville Sharp and Simon, Inc.
Architects

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INTRODUCTION

The roofing industry is presently in a phase of rapid change. Bituminous built-up roofing which has been the only choice for a roofing membrane in this country is currently being challenged by a wide variety of materials known collectively as single-ply roofing.

Single-ply roofing is the term used to describe a group of roofing products that are applied in a single layer. While many of these new products are actually composite sheets comprised of several different materials, they are combined in the factory so that the applicator in the field can install the membrane in one step. This is in direct contrast to built-up roofing where the different materials that make up the finished product are shipped to the job site and basically manufactured on the roof in a multi-layer application.

The single-ply concept originated in Europe in the late 1950's, with the most common products consisting of P.V.C. membranes and modified bitumens. Some single-ply products were manufactured in the United States in the early 1960's, notably synthetic rubber products, but these products did not at that time gain a significant share of the market place. While some single-ply products were installed in the United States during the 60's and early 70's, the quantity of these products was insignificant when compared to the total roofing market in this country.

In the early 1970's the energy crisis hit the industrialized world, causing the price of oil-derived products to skyrocket while the availability of these materials decreased. At the same time there began a perception on the part of owners and architects that traditional built-up roofing was becoming unreliable and short-lived. With the cost of built-up roofing rapidly increasing and the reliability of the material doubted, the stage was set for a new type of roofing product.

The single-ply roofing products that began to move into the market at this time were of two types. The first material was the single-ply membrane imported from Europe, specifically P.V.C. products. The second type is the synthetic rubber product that was developed primarily in this country. While some products tried were initially failures, enough success was enjoyed by these systems that they steadily gained acceptance in several areas of the country. The steady gains of the middle and late 70's became a landslide in the 80's as more and more products entered the market and as single-ply products came into use in almost all parts of the country.

This proliferation of products and of different materials has become quite confusing to most owners and building designers. They are constantly being bombarded with claims from different product manufacturers and representatives of the superiority of one product over another. While leaky roofs are a large problem for most building owners and designers, they rarely have the time to more than superficially investigate the claims of the single-ply representatives. Industry standards for most materials have not yet been developed and are probably several years away from reality. Owners and designers are usually left to their own experiences and intuition in selecting materials and systems for use on their roofs.

This report is an attempt to assist the building owner or designer in the selection of single-ply roofing products. The major material groups are described, along with their characteristics and limitations. Also, the important criteria for the selection of single-ply membrane systems are outlined along with the physical characteristics needed by the roofing membrane to perform on different size roofs.

While not every type of single-ply material now available could be evaluated, this report has tried to analyze those materials which represent the majority of the single-ply roofing market. In addition, this report has limited itself to only factory produced sheet membranes and has made no attempt at an evaluation of liquid applied or sprayed applied systems.

GENERIC PRODUCTS

A very simple and basic item concerning single-ply roofing in bidding procedures is that all products of a specific material are not created equal. Unfortunately this simple fact is often overlooked, and this invariably can lead to trouble for the unwary building owner or designer.

Writing generic specifications for a single-ply material can lead to the building owner getting a product far different from what was anticipated during the design stage of the project. Several types of single-ply materials are now being manufactured or marketed by a large number of firms. This is particularly true of E.P.D.M., P.V.C. and modified bitumens.

E.P.D.M. materials, for an example, are manufactured in the United States by a relatively small number of manufacturers, most of whom sell their product under their own corporate name. Some manufacturers though, do not market their own material, but sell to independent companies who sell the material under their own names. Also, there are several companies who import and sell E.P.D.M. materials that are manufactured in various foreign countries.

These companies who market materials produced by others do not necessarily have a significant amount of working capital or assets. This is important when considering the guarantees that are issued by these companies. A ten-year guarantee from a company which, if beset by a number of roofing failures will be out of business in just a few years, is not much protection for the building owner.

In addition, companies who do not produce their own membranes are at the mercy of others when it comes to quality control, delivery of materials, and technical expertise. This last item can be a significant factor when unusual situations arise which require factory assistance. Companies which are basically set up as a marketing firm may not have the necessary technical people to help the contractor and building owner if problems arise on the job.

It is important to realize that almost all materials differ in some respects from other, similar products. P.V.C. materials depend heavily on proprietary formulation for their weathering and aging properties. Products which look the same, contain the same reinforcement, are the same thickness, and the same color may not age the same. One product may last twenty years or more in actual use while the other deteriorates in two or three years.

E.P.D.M. systems depend upon the blend of different fillers and processing oils with the E.P.D.M. not only for the characteristics of the membrane, but also for the compatibility with the adhesives used to bond the sheets to one another. The strength of the seam of two different manufacturer's E.P.D.M. systems using the same adhesives may vary widely.

Most companies producing their own membranes do not manufacture their own adhesives, but purchase it from another source. These adhesives, which were made to work with a particular membrane, may not work as well on membranes from different sources. Therefore, the strength of the seam will vary from system to system, depending on the composition of the sheet.

As a rule, generic specifications should be avoided. The owner and designer should decide which materials and specific products are to be used and write the specifications around these products. The desired properties of the specified product should be outlined and known to the owner or designer. Any material supplier who asks for approval to bid on the project should be required to show that he meets all of the properties and standards of the specified product.

It is not recommended that any product be accepted to bid on a project unless there is enough time to thoroughly investigate the material. It should be expected that the material supplier requesting approval will supply the owner with all of the necessary information to evaluate his product. If this information is not promptly supplied, the material should not be considered. It should not be required of the owner to accept every similar single-ply roofing product on the market as an equal to a specified material.

Not only should chemical make-up and physical properties be considered, but exposure history, quality control, the warranty, and financial ability to back the warranty should all be considered. While a truly equal product should be allowed to bid on a project, an inferior or untested product should not be forced on the owner just because of the manufacturer's claim of being "just as good".

WORKMANSHIP

In built-up roofing, workmanship does not necessarily have to be of a high quality for the system to be successful. In single-ply roofing, however, the skill of the workmen on the job is all important. Coping with this radical change in the way a roofing system is applied has and probably will continue to be difficult for the majority of roofers.

A roofing contractor and his crew who are used to the traditional built-up roofing method, which by its nature is not a clean, meticulous operation, have a hard time adjusting to the cleanliness and thoroughness required with most single-ply systems. Not only have the materials and tools necessary to install a roof changed but the attitude of the roofer must change before he can become competent installing single-plys.

To correctly install a single-ply roofing system requires a series of steps which must be correctly executed in order for the system to perform as designed. If the installer does not strictly adhere to the manufacturer's instructions, he may be building in a fault which, though not immediately apparent, will eventually cause the failure of the system. For example, in P.V.C. systems, manufacturers recommend that the membrane be allowed to relax after the membrane is unrolled on the job. If this is not done, stress will be built into the system since the membrane has a tendency to shrink after it comes off the roll. This can lead to premature failures as the material shrinks and pulls out its perimeter fastenings.

The roofing contractor and his workmen must learn all aspects of the system they intend to install. They must learn what will happen if a necessary procedure is left out or changed, what materials are and are not compatible with the system(s) they are applying, how to best apply the system(s), and what the limitations of the material(s) are.

This learning period is not a quick and easy process. Unfortunately, familiarity with a roofing system comes only through experience, experience which is sometimes painful. Those roofers who learn from their mistakes, or are careful enough to avoid making their own errors will become qualified single-ply roofers. Those contractors who cannot learn from their mistakes will hopefully be driven from the field by either economics or by virtue of a bad reputation.

The best method for an owner or designer to protect himself is to demand that all contractors have experience with the single-ply system they intend to apply and to ask for and check out references. It is important to investigate as many of the references as possible to find out:

(1) What roofing system was actually installed
(2) How did the system perform
(3) Was the job completed within a reasonable time
(4) Was the owner or designer satisfied with the performance of the contractor.

Even if the contractor appears knowledgeable about the roofing system and his references appear good, it is advised that the owner have his own inspector on the job site to ensure that the quality of workmanship is to the owner's satisfaction. It cannot be stressed enough that the level of the workmanship must be very good; that during construction the substrate surface must be properly prepared and all materials properly stored and kept dry; that at the end of the job, the roof must appear neat and that all seams, joints, flashings, etc., must be carefully sealed.

The quality of the workmanship when installing any single-ply material is most probably going to be the determining factor in whether or not the roof will perform successfully. While certain materials may have superior qualities over others, any single-ply roof will fail if improperly installed. Good workmanship has been, is, and will continue to be a necessary part of any good single-ply system.

When choosing a single-ply roofing product, the type and quantity of training that the contractor receives from his material supplier should be looked at carefully. Without factory or field training, field inspection and follow-up inspections, good workmanship cannot be assured. The manufacturer should have a good program for contractor training and quality control in operation. If they do not, it might indicate a lack of commitment to quality work that should not be accepted by the owner. Those companies that are only interested in selling their product and are not particularly concerned with the longevity of their roofs should be avoided.

WARRANTIES

To gain acceptance for their products, most single-ply manufacturers offer limited warranties with their products. The number of years that the warranties are in force vary, but the most common are either five or ten-year warranties. These warranties were offered primarily to gain acceptance from owners and specifiers of roofing products for materials that had relatively little exposure history from which to base the material life expectancy. It should be noted, however, that in offering these "limited" warranties, the product manufacturers have also limited their own liabilities.

The warranties vary from manufacturer to manufacturer, but for the majority of warranties they cover the same basic points. They normally state what is covered by the warranty, how long the warranty is in force, and the terms, conditions, and limitations of the warranty. Before accepting any warranty, it should be carefully scrutinized to see whether it protects the owner or signs away the owner's rights to seek redress in case of a major failure in the roofing system.

Most warranties are not roof system warranties, but are only material warranties. A material warranty will guarantee that if the membrane is defective, or deteriorates due to weather, then it will be replaced. Sometimes only new replacement material is provided, but usually the warranty will state that the labor cost involved in replacing the old material is also covered. These material warranties generally do not state that it covers the cost of new insulation, fasteners, counterflashing, adhesives, and other accessories needed to install a new roof. This type of protection for the owner is found only in a roof system warranty.

The owner who accepts a single-ply material warranty and thinks he is protected from roof leaks for ten years may find out that he must pay for more than half the cost of any major repairs. A roofing system warranty would cover the full costs of all labor and replacement materials necessary to repair the roof to a watertight condition. Some manufacturers now offer such a warranty and hopefully more will offer these roofing system guarantees in the near future.

Another part of the standard warranties that should be scrutinized is the terms, conditions, and limitations as written by the manufacturer. Many warranties have several items written in these sections that allow the manufacturer to declare the warranty null and void if they so desire. One should be wary of ambiguous phrases or definitions, such as requiring the owner to take reasonable care in maintaining the roof. What constitutes "reasonable care"? Where is that defined? Will the manufacturer provide the owner with a maintenance manual so that the owner will know how to take care of the new roof, or will these items only be "discovered" in the case of a failure?

Another area of concern is the manufacturer's definition of natural disasters. Many warranties have disclaimers covering earthquakes, lightning, hurricanes, tornadoes, gales, and or windstorms. While the first four items listed are legitimate natural disasters that would normally cause severe structural damage to a building, the last two are not.

The term windstorm has no climatologic definition, it is defined in the Webster's Dictionary as "a storm with a strong wind but little or no rain". This is a very loose definition to put into a warranty. How one defines the word strong has a great deal of bearing on the subject. To one person a strong wind might be as little as 30 miles per hour while another might argue it as much higher.

The term gale, while better defined, does not leave the owner much better off. A gale force wind can be as low as 39 miles per hour. The uniform building code, 1982 edition, states that every building or structure and every portion thereof shall be designed and constructed to resist the wind effects determined in that portion of the code pertaining to wind loads. A wind map in that section gives minimum wind speeds that are to be used in the design of buildings. The lowest wind speed on the map is 70 miles per hour. Thirty-nine miles per hour is therefore thirty-one miles per hour below the minimum wind speed allowed by the U.B.C.

Many areas of the country experience wind speeds in excess of 39 m.p.h. several times a year. Therefore, if the roof should fail during a storm where the winds exceeded 39 m.p.h., the manufacturer could conceivably avoid repairing the roof. Since this might occur several times a year, the owner risks having to bear the cost of a blow-off. Obviously this is not a situation in which most owners would wish to place themselves. It is recommended that this be avoided if at all possible unless the owner has complete confidence in the roofing system and realizes the risk involved.

The owner should realize that in accepting the manufacturer's material warranty, he gives up a great deal of protection from state laws governing merchantability and fitness of use. While these laws vary from state to state, often they will provide more protection than a standard material warranty. The disadvantages of relying on state laws is that they vary from state to state and to seek redress it may be necessary to start legal proceedings. This can be a long process when a building roof is leaking or has been severely damaged. A good roof system warranty is a better and quicker way of handling responsibility for repairing a roof.

Some large institutions and state governments have written their own guarantees and require its use on their respective roofing work. These warranties normally cover the entire roof systems including: membrane, insulation, adhesives, fasteners, vapor retarder, and flashings provided by the single-ply manufacturer. It is important, however, to have written acceptance of the warranty from the single-ply membrane manufacturers before the bids are received.

These institutional roofing warranties offer their owners a far greater degree of protection than the standard material guarantee. By covering all of the labor to remove and replace a defective roof, as well as all necessary accessories, it gives the owner a much more complete coverage than would otherwise be available. Another advantage is that the owner can tailor the warranty to fit his individual needs. The standard material warranties are usually constructed to protect the manufacturers, while the institutional roofing warranties can be constructed to protect the owners.

It must be remembered, however, that the manufacturers must agree to sign the warranty before it can be of use to the owner, so the warranty cannot be too one-sided. Therefore, the warranty must be fair to all sides and negotiations with the manufacturers may be necessary during the planning of the institutional warranty.

It is best to have a standardized letter of certification, distributed by the institution issuing the warranty, that is signed by an authorized representative of the manufacturer and returned with the bids. This letter of certification should state that the manufacturer's technical staff has reviewed the specifications and drawings and that if their recommended installation procedures are followed, they will issue the institution's warranty. Hopefully this will encourage the manufacturer to review the project before it is bidded and to note any objections.

An institutional roofing warranty can also eliminate ambiguous phrases and better define all other gray areas. It should be understood, however, that the single-ply manufacturers must agree to sign the institution's warranty before it is useful. Also the manufacturer must have the financial capability to absorb the loss from having to make repairs on warranted roofs. Only reputable, financially sound manufacturers of dependable single-ply membrane systems should be allowed to bid on projects.

A roofing system warranty should not be used as a substitute for the selection of dependable roofing materials. The warranty should always be considered as the back-up measure only. One does not go into a project expecting to use the warranty - hopefully it will not be necessary. If a failure occurs, however, it is good to know what is covered by the manufacturer before the roof begins to leak.

Included at the back of this section are several sample warranties from a variety of manufacturers and a copy of the University of Missouri roofing system manufacturer's warranty. These warranties are for inspection only, this report does not approve or disapprove of any of the sample warranties shown.

Summary

The standard manufacturer roofing membrane warranties are in reality only material guarantees. They usually only protect the owner from failures due to defective materials or premature deterioration of the membrane. They do not protect the owner from a roof failure due to high winds or failure of any part of the roof system other than the membrane.

A good roof system warranty should guarantee all parts of the roof, from the deck up, in place and for all normal climatic conditions. The roof should be expected to withstand the same forces as the other parts of the building such as walls, windows, etc.

Carlisle SynTec Systems

Carlisle SynTec Systems
Division of Carlisle Corporation
P.O. Box 7000
Carlisle, PA 17013
(717) 245-7000; Telex 84-2511 (SynTec CLSL)

Serial No. TS ....

CARLISLE GOLDEN SEAL™ A TOTAL ROOFING SYSTEM WARRANTY FOR COMMERCIAL BUILDINGS

Building Owner: ....
Building: ....
Location: ....
Date Installation is Completed: ....
Date Inspection of Installation is Completed: ....

CARLISLE SYNTEC SYSTEMS, DIVISION OF CARLISLE CORPORATION, ("CARLISLE") warrants to the Building Owner, ("Owner"), of the commercial building described above, that subject to the terms, conditions, and limitations stated herein. Carlisle will repair any leaks in the Carlisle Golden Seal Total Roofing System, but Carlisle's obligations shall not exceed the Owner's original cost of the installed roof over the life of this Warranty, installed by a Carlisle Authorized Roofing Applicator, for a period of 15 years commencing with the date of the final inspection and acceptance of the Total Roofing System installation by Carlisle. This warranty does not cover Hypalon coating used to coat the membrane and flashing.

The Total Roofing System includes the following Carlisle materials for the roof described above:
A. Membrane B. Insulations C. Adhesives D. Fasteners/Insulation Plates E. Fastener Bars
F. Hard Rubber Edging G. Counterflashing H. Any other material supplied, or specifically approved by Carlisle as listed: ....
....

TERMS, CONDITIONS, LIMITATIONS

1. Owner shall provide Carlisle with written notice within thirty (30) days of the discovery of any leaks in the Total Roofing System
2. If upon Carlisle's inspection, Carlisle determines that the leaks in the Total Roofing System are caused by defects in the Carlisle Total Roofing System's material or workmanship of the Carlisle Authorized Roofing Applicator, Owner's remedies and Carlisle's liability shall be limited to Carlisle's repair of the Total Roofing System
3. This Golden Seal Total System Warranty shall not be applicable if any of the following shall occur
   (a) The Total Roofing System is damaged by natural disasters, including, but not limited to lightning, strong gales, hurricanes, tornadoes, earthquakes or
   (b) The Total Roofing System is damaged by any acts of negligence, accidents, or misuse, including but not limited to vandalism, civil disobedience, or acts of war
4. This Warranty shall be null and void if any of the following shall occur
   (a) If after installation of the Total Roofing System by a Carlisle Authorized Roofing Applicator there are any alterations or repairs made on or through the roof or objects such as, but not limited to, structure, fixtures, or utilities are placed upon or attached to the roof without first obtaining written authorization from Carlisle or
   (b) Failure by the Owner or lessee to use reasonable care in maintaining the roof, or
   (c) Owner fails to comply with every term or condition stated herein
5. During the term of this Warranty, Carlisle, its agents or employees, shall have free access to the roof during regular business hours
6. Carlisle shall have no obligation under this Warranty until all bills for installation, supplies, and service have been paid in full to the Carlisle Authorized Roofing Applicator and material suppliers
7. Carlisle's failure at any time to enforce any of the terms or conditions stated herein shall not be construed to be a waiver of such provision
8. This Warranty supersedes and is in lieu of any and all other expressed warranties that are in conflict with the terms and conditions stated herein

THE REMEDIES STATED HEREIN ARE THE SOLE AND EXCLUSIVE REMEDIES FOR FAILURE OF THE ROOFING SYSTEM OR MEMBRANE. THERE ARE NO WARRANTIES EITHER EXPRESSED OR IMPLIED WHICH EXTEND BEYOND THE FACE HEREOF. CARLISLE SHALL NOT BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR OTHER DAMAGES INCLUDING, BUT NOT LIMITED TO, LOSS OF PROFITS OR DAMAGE TO THE BUILDING OR ITS CONTENTS.

CARLISLE SYNTEC SYSTEMS
DIVISION OF CARLISLE CORPORATION
BY: ....
AUTHORIZED
SIGNATURE: ....
TITLE: ....
DATED: ....

Warranty

Warranty Serial No.

SARNAFIL ROOFING MEMBRANE WARRANTY FOR COMMERCIAL BUILDING

Building Owner

Building Name used as

Date of Completion of Installation

Date of Inspection of Installation by

SARNAFIL (U.S.) INC. (Sarnafil), warrants to the owner of the building described above ("Owner"), that subject to the terms, conditions, and limitations stated herein, Sarnafil will repair any leaks to the Sarnafil Roofing Membrane ("Roofing Membrane") installed according to Sarnafil's Technical Instructions by a Sarnafil Authorized Roofing Contractor for a period of years commencing with the date of final inspection and acceptance of the Roofing System by Sarnafil.

TERMS, CONDITIONS, LIMITATIONS

1. Owner shall notify Sarnafil in writing within thirty (30) days of the discovery of any leaks in the Roofing System.
2. If, on Sarnafil's inspection, Sarnafil determines that leaks in the Roofing System are caused by defects in Sarnafil's material or workmanship of the Sarnafil Authorized Roofing Contractor except as provided in the following paragraphs three (3) and four (4), Owners remedies and Sarnafil's liability shall be limited to Sarnafil's repair of the Roofing Membrane.
3. This warranty shall not be applicable if any of the following shall occur:
   (a) The Roofing Membrane is damaged by natural disasters, including, but not limited to, earthquake, lightning, hurricanes, and tornados, or:
   (b) The Roofing Membrane is damaged by any acts of negligence, accidents, or misuse, including, but not limited to, vandalism, civil disobedience, or acts of war, or:
   (c) Metal work or other roofing accessories or equipment not furnished by Sarnafil is used in the Roofing System and causes leaks.
4. This warranty shall be null and void if any of the following shall occur:
   (a) If, after installation by the Authorized Roofing Contractor there are any alterations or repairs made on or through the roof, or objects such as but not limited to fixtures, equipment, or structures are placed on or attached to the roof without first obtaining written authorization from Sarnafil, or
   (b) Failure by the Owner or his lessee to use reasonable care in maintaining the roof, or:
   (c) A significant change in the use of the building by the Owner or his lessee thereby affecting the Roofing Membrane as originally installed, or:
   (d) The Owner fails to comply with every term and condition stated herein.
5. During the period of this warranty, Sarnafil, its agents and employees, shall have free access to the roof during regular business hours.
6. Sarnafil shall have no obligation under this warranty until all bills for materials, installation, and services have been paid for in full.
7. Sarnafil's failure at any time to enforce any of the terms or conditions stated herein shall not be construed to be a waiver of such provision.
8. No other warranty, express or implied, is given. Sarnafil shall not be liable for any incidental or consequential damages resulting from any breach of warranty including, but not limited to, damage to the building on which the products are situated, damage to the contents thereof or to any other property or persons.
9. Any disagreement arising from the above will be resolved through the American Arbitration Association.

NO REPRESENTATIVE OF SARNAFIL HAS AUTHORITY TO MAKE ANY REPRESENTATIONS OR PROMISES EXCEPT AS STATED HEREIN.

SPECIMEN

Sarnafil

Canton Commerce Center, Canton, Massachusetts 02021 • Telephone: (617) 828-5400 • Telex: 951625

By

Authorized Signature

Title

Dated

This Warranty is effective from ____________________ through ____________________

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Carlisle SynTec Systems

Carlisle SynTec Systems
Division of Carlisle Corporation
P.O. Box 7000
Carlisle, PA 17013
(717) 245-7000; Telex 84-2511 (SynTec CLSL)

Serial No. ....

CARLISLE SURE-SEAL™ MEMBRANE SYSTEMS WARRANTY FOR COMMERCIAL BUILDINGS

Building Owner: ....
Building: ....
Location: ....
Date Installation is Completed: ....
Date Inspection of Installation is Completed: ....
Roof Approved By: ....

Carlisle SynTec Systems, DIVISION OF CARLISLE CORPORATION, ("CARLISLE"), warrants to the Building Owner, ("Owner"), of the commercial building described above, that subject to the terms, conditions, and limitations stated herein, Carlisle will repair any leaks in the Carlisle Sure-Seal™ Membrane System ("Membrane System"), but Carlisle's obligations shall not exceed the Owner's original cost of the installed membrane over the life of this Warranty, installed by a Carlisle Authorized Roofing Applicator for a period of .... years commencing with the date of the final inspection and acceptance of the Membrane System installation by Carlisle.

TERMS, CONDITIONS, LIMITATIONS

1. Owner shall provide Carlisle with written notice within thirty (30) days of the discovery of any leaks in the Membrane System.
2. If, upon Carlisle's inspection, Carlisle determines that the leaks in the Membrane System are caused by defects in the Carlisle Membrane System's material or workmanship of the Carlisle Authorized Roofing Applicator, Owner's remedies and Carlisle's liability shall be limited to Carlisle's repair of the Membrane System, subject to the cost limitation set forth above.
3. This Warranty shall not be applicable if any of the following shall occur:
    (a) The Membrane System is damaged by natural disasters, including, but not limited to, lightning, strong gales, hurricanes, tornadoes, and earthquakes, or
    (b) The Membrane System is damaged by any acts of negligence, accidents, or misuse, including but not limited to, vandalism, civil disobedience, or acts of war, or
    (c) Metal work or other material not furnished by Carlisle is used in the Membrane Systems and causes leaks.
4. This Warranty shall be null and void if any of the following shall occur:
    (a) after installation of the Membrane System by a Carlisle Authorized Roofing Applicator there are any alterations or repairs made on or through the roof or objects such as, but not limited to, structures, fixtures, or utilities are placed upon or attached to the roof without first obtaining written authorization from Carlisle, or
    (b) Failure by the Owner or lessee to use reasonable care in maintaining the roof, or
    (c) Owner fails to comply with every term or condition stated herein.
5. During the term of this Warranty, Carlisle, its agents or employees, shall have free access to the roof during regular business hours.
6. Carlisle shall have no obligation under this Warranty until all bills for installation, supplies and service have been paid in full to the Carlisle Authorized Roofing Applicator and material suppliers.
7. Carlisle's failure at any time to enforce any of the terms or conditions stated herein shall not be construed to be a waiver of such provision.
8. This Warranty supersedes and is in lieu of any and all other expressed warranties that are in conflict with the terms and conditions stated herein.

THE REMEDIES STATED HEREIN ARE THE SOLE AND EXCLUSIVE REMEDIES FOR FAILURE OF THE ROOFING SYSTEM OR MEMBRANE. THERE ARE NO WARRANTIES EITHER EXPRESSED OR IMPLIED WHICH EXTEND BEYOND THE FACE HEREOF. CARLISLE SHALL NOT BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR OTHER DAMAGES INCLUDING, BUT NOT LIMITED TO, LOSS OF PROFITS OR DAMAGE TO THE BUILDING OR ITS CONTENTS.

CARLISLE SYNTEC SYSTEMS
DIVISION OF CARLISLE CORPORATION
BY: ....
AUTHORIZED
SIGNATURE: ....
TITLE: ....
DATED: ....

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UNIVERSITY OF MISSOURI
ROOF SYSTEM MANUFACTURER'S CERTIFICATION
(Revised 11/8/82)

TO:

Project No.
Title

Location

Our technical staff has examined the Architect/Engineer's drawings, specifications and required warranty for the roofing work on this project. We do not wholly endorse the building design or any materials or services not part of our advertised roofing system.

CERTIFICATION

We hereby certify that:

1. All materials we will furnish and deliver to the project will be of good merchantable quality, will meet or exceed the specification requirements and will, if properly applied by one of our approved roofing applicator firms in accord with our instructions, provide a sound weather/watertight roofing system.

2. Upon completion of the installation in accord with the drawings and specifications and our recommended installation procedures, we will issue the warranty specified in the project specifications, University of Missouri Roofing System Manufacturer's Warranty.

3. The drawings and specifications follow the recommendations of our roofing manual for this type of roofing system with:
   No exceptions.
   The following exceptions: (The Roofing System will be approved for this project if the following changes are made to the contract documents. The bid provided with this document includes the required changes.)

   Note: Exceptions may cause Owner to reject bid.

4. The Warranty will be issued for the following proposed roofing system: ______________________
____

ROOFING SYSTEM MANUFACTURER ______________________________
Authorized Signature: ______________________________
Title ______________________ Date: ______________________
Telephone Number: ( ) ______________________________

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UNIVERSITY OF MISSOURI

ROOFING SYSTEM MANUFACTURER'S WARRANTY
(Revised 11/8/82)

Roofing System Manufacturer:______________
Name______________________________________
Address___________________________________
____
Room Area_________________________________
Roof Specification________________________
Lin.Ft.Flashing___________________________
Lin.Ft.Expansion Joint Covers_____________
Insulation Type___________________________

UM Project No.____________________
Building Owner____________________
Owner Address_____________________
____
Building Name_____________________
Building Address__________________
Roofer Name_______________________
Address___________________________
Telephone_________________________

I. WARRANTY

A. The Roofing System Manufacturer, identified as ____, a _____________________ Corporation with its principal office at ____ hereinafter called "Manufacturer" warrants to the University of Missouri hereinafter called "Owner" that, subject to the provisions of this of this document, the Manufacturer will, at its own expense, make or cause to be made all repairs necessary to maintain the roofing system in a watertight condition for a period of ten years from the date of accepted substantial completion of the roofing system.

B. System includes"
   1. Membrane(s).
   2. Flashings (except metal or composite metal components not furnished by the Manufacturer as part of its advertised system).
   3. Insulation (Approved or supplied by manufacturer).
   4. Vapor retarder.
   5. Fasteners and adhesives.

C. Limitation: The Manufacturer's liability under this Warranty shall be limited to ($_________________) which is the Owner's original cost of the installed roofing system.

II. OWNER'S RESPONSIBILITY. The Owner will notify the Manufacturer if repairs covered by the Warranty are required. The notice will be sent by Certified Mail, return receipt requested, to the Manufacturer's office specified in the Manufacturer's Maintenance Manual within 30 days of discovery of leaks or other defects in the roofing system. The Owner may, at his option, make any emergency repairs to the roof as required until all permanent repairs are made by the manufacturer. The Owner will make every effort to phone the manufacturer before the repairs are made. The Owner will provide the Manufacturer free access to the building during regular business hours over the life of the Warranty. The Owner acknowledges that the Manufacturer has provided its Roofing Maintenance Manual, including instructions necessary for the Owner to inspect and maintain the roofing system during the warranty period.

III. EXCLUSIONS

A. The following are excluded from this Warranty:

1. Roof maintenance.
2. Damage to any part of the building (other than the roofing system) or to its contents.
3. Damage resulting from repairs made to the roofing system which are not per Manufacturer's recommendation.
4. Damage resulting from any one of the following:
    - a. Cracking, warping, deflection or movement of building foundation.
    - b. Natural disasters (i.e., winds at 6 feet above the ground in excess of 54 miles/hr., hail larger than 1½ inches in diameter, flood, hurricane, lightning, tornado or earthquake).
    - c. Accidents, vandalism or other uncontrollable events.
    - d. Chemical attacks on the membrane from sources not present at time of roofing system installation.
    - e. Falling objects, misuse or abuse of the roofing system, recreational activities or storage of material on the roofing system.
    - f. Infiltration or condensation of moisture in, through or around walls, copings, buildings structure or underlying or surrounding areas.
    - g. Movement or deterioration of metal components adjacent to the roof (except where such components are a part of the Manufacturer's advertised roofing system).
    - h. Tests of test cuts not authorized by the Manufacturer.
    - i. Failure of the Owner to provide maintenance in accordance with the Roofing Maintenance Manual.
    - j. Failure of Owner to notify the Manufacturer of leaks or other defects within 30 days of discovery.
    - k. Changes in building usage; new installations on, through or adjacent to the roofing system made after the effective date of this Warranty, unless the Manufacturer has given prior written approval of such changes in building usage or new installations.
    - l. Failure of materials supplied by others (except where such materials are a part of the specified roofing system certified by the Manufacturer prior to bidding the roofing work) unless approved by roofing manufacturer.

B. **The implied warranties of merchantability and fitness for a particular purpose are excluded.**

In Witness Whereof: Manufacturer and Owner have caused this Warranty to be duly executed on the above date.

MANUFACTURER	OWNER
By ______________________________	By ______________________________
Title ______________________________	Title ______________________________
Date ______________________________	Date ______________________________

(Revised 5/83)

MATERIALS

- P.V.C.
- C.P.E.
- C.S.P.E.
- E.P.D.M.
- Polychloroprene
- Modified Bitumen

P.V.C. - POLYVINYL CHLORIDE

Polyvinyl chloride or P.V.C. is one of the earliest types of single-ply roofing. Originally developed in Europe, it has been in use for almost twenty years. Polyvinyl chloride is the largest volume member of the vinyl family with the following basic properties: chemically inert; water, corrosion, and weather resistant; high strength-to-weight ratio; tough; dirt-resistant; an electrical and thermal insulator; and maintains properties over long periods of time.

P.V.C. is by its nature a rigid material, far too inflexible for use as a roofing material. To transform the basically rigid P.V.C. into a suitable roofing membrane, it is necessary to add plasticizers and stabilizers to the P.V.C. resin. In addition, pigments are added for color and fillers are added to reduce the cost of the membrane.

P.V.C. resin is manufactured in a powder or granule form and is available in various grades and types. For flexible P.V.C. compounds such as those used for single-ply systems, high molecular weight resins are preferred because they help develop maximum physical properties typified by high tensile strength and modulus of elasticity.

It is important to realize that commercial resins do vary in their heat stability characteristics. Thus, if one P.V.C. resin is substituted for another, it might be necessary to alter the stabilizer system. Stabilizers not only inhibit the decomposition of P.V.C. but it also tends to direct degradation.

The physical properties as well as heat stability and processing features of the vinyl compounds are directly proportioned to the molecular weight. The specific viscosity is commonly used to characterize the polymers' molecular weight.

In the selection of plasticizers, the significant properties associated with plasticizers must be considered. These properties are: compatability with the P.V.C. resin, ability of the material to resist extraction from the finished product, and the efficiency of the material to neutralize the Van der Wall forces between the polymer molecules.

When looking at plasticizers, one must understand that there are two types of plasticizers, primary and secondary. When a material can be used as the sole or major plasticizer component without danger of loss, it is generally considered to be a primary plasticizer. A secondary plasticizer might be extracted from the membrane. That is, the difference between primary and secondary plasticizers is the compatability with the P.V.C. resin. Moreover, there are degrees of compatability within plasticizer series.

Usually secondary plasticizers are added to reduce cost, but they also are added to enhance certain desirable characteristics of the single-ply membrane. Phosphate plasticizers are added to vinyl formulations to enhance its flame resistance, epoxy plasticizers will enhance the heat and light stability of some metallic stabilizer systems, and with other stabilizers will provide protection against the degradation of outdoor weathering. If these plasticizers are lost, then these necessary properties will be reduced.

Plasticizer loss can be caused through either migration to the backing, evaporation to the environment, or by hydrolysis. Shrinkage of the material is directly related to the loss of plasticizer. This shrinkage causes the P.V.C. to regain stress, even in loosely laid applications. Embrittlement through plasticizer loss and with it the regaining of stress in the material occurs slowly, through many cooling and heating cycles. It can therefore be understood why failures in the membrane may not occur until several years after installation.

This shrinkage of the P.V.C. membrane due to plasticizer loss is an inherent problem with P.V.C. material that cannot be avoided with a homogeneous membrane. This problem can be overcome, however, with the introduction of reinforcement that can not only reduce shrinkage but can have a significant positive effect on the tensile strength of the material.

It can be shown that coated materials behave more uniformly than non-coated membranes. Reinforcement, however, is not a guarantee for success. The type of reinforcement and method of manufacturing the material are also important. There is no one reinforcement or method of manufacturing that can be pointed out as correct. The finished product and its performance must be looked at on an individual basis.

The designer or owner must look at the desired performance of the material in relationship with the type of project and application intended. The type of building and attachment method preferred will determine the requirements needed by the single-ply membrane to perform successfully as a roofing product.

At this time, industry wide standards have not yet been established, but this report will attempt to give guidelines that can be followed in the selection of single-ply P.V.C. membranes.

It is advisable to select a material that has as low a shrinkage rate as possible. This is particularly crucial in an adhered application. For an adhered application, it is also essential that the rate of thermal expansion be as low as possible so that it can match the thermal expansion of the substrate to which it is adhered. One must remember that even with a low rate of thermal expansion, a high rate of shrinkage cannot be tolerated.

The elongation capability of a material has to be looked at in conjunction with both the tensile strength of the material and the intended installation procedure. The higher the tensile strength of the material, the lower the allowable elongation capacity. Naturally, there is a certain amount of elongation capacity needed no matter what the tensile strength of the membrane. In addition, for mechanically attached systems, a higher tensile strength is desirable.

While a lot of attention has been focused on extremely high elongation capacities, usually it is not necessary to have 200% - 300% elongation in a single-ply membrane. This capacity is only needed in a material that has an extremely high rate of thermal expansion. A more reasonable range of elongation capacity for a thermally stable material is somewhere between 20% - 50%. A lightweight steel structure will not thermally move anywhere near this range. Barring movement that would be detrimental to the building structure, 20% - 50% elongation ability in the single-ply membrane should be sufficient.

The tensile strength requirements of the P.V.C. membranes vary depending on the attachment method used to secure the roof to the building structure. For ballasted roofs, the tensile strength of the material does not have to be as great as when the roof is secured by mechanical fasteners. This is because the forces for ballasted and adhered roofs are uniformly distributed over the entire membrane, while with the mechanically fastened system the loads are concentrated at the plates or bars.

The most common figures for either non-reinforced or glass fiber reinforced membranes are generally between 1400 psi and 1800 psi. These figures are far in excess of any real-life forces that the material might experience as a single-ply roofing membrane. With a mechanically attached P.V.C. roofing system, most membranes claim tensile strengths over 2200 psi. Again, it would be difficult for the membrane ever to experience forces anywhere near their rated strength.

This excess capacity in the material, in both elongation ability and tensile strength allows for a loss of properties due to aging and for a factor of safety for less than ideal installations. It also allows for a comparison of quality between manufacturers. If a membrane's physical properties are significantly below that of similar systems, one might legitimately question the quality of the weaker material.

The physical properties most often quoted by the manufacturers for their materials such as elongation, tensile strength, UV resistance, etc., do not really give any indication of the material's abilities to withstand the effects of the environment over a period of time. This ability can only be determined by the successful use of the system over a number of years. With P.V.C. membranes, we recommend an exposure history in the United States of between 5 - 10 years. There are several manufacturers who can now match that criteria, some with a good track record and others with problems.

European exposure histories do not truly indicate whether a P.V.C. membrane will perform well in the United States. Most of Europe lies above 40 degrees latitude while 3/5 of the continental United States lies below 40 degrees latitude. In addition, the interior of this country experiences both warmer summers and colder winters than most of Europe. Even Saudi Arabia, where several European membranes have considerable experience, is not a very good testing ground for use in the United States. This is due to the extreme lack of rain and thunderstorms in Saudi Arabia when compared to Texas, Georgia, Louisiana, and Florida. Saudi Arabian exposure is, however, a good indication of U.V. resistance.

Installation methods for P.V.C. roofing membranes must be carefully followed to properly install the system. P.V.C. membranes can be installed either loose-laid ballasted, mechanically fastened or fully adhered. The individual P.V.C. sheets can be seamed using a solvent (usually THF) or hot air welded.

The loose-laid ballasted system is the most common method of applying a P.V.C. membrane, and often the most economical. As described earlier in this report, it consists of loosely applying the vapor barrier (if needed), slip sheet (if required), insulation, and membrane, joining all required seams, and fastening the membrane at the perimater and all roof penetrations. This assembly is then ballasted with gravel or other appropriate ballast material at a rate as recommended by the manufacturer, usually 8 to 12 pounds per square foot. This method can also be modified by installing suitable insulation on top of the membrane and then installing ballast on the insulation board. This is commonly called the protective membrane system.

The mechanically fastened system for P.V.C. membranes is offered in several forms. In this system, the membrane can be solvent welded to disks that are mechanically fastened to the deck at intervals laid out by the manufacturer. Another variation is to loosely lay the membrane over the deck and then mechanically fasten plates through the membrane and insulation to the deck. These plates are then covered with a small piece of membrane that is then either solvent or hot air welded to the main sheet. A third method of mechanical attachment is to install plates or bars at the edge of a sheet of membrane, fasten the plates or bar through the membrane to the deck, and then lap over another sheet of P.V.C. membrane to cover the mechanically fastened plates or bar. Any of the above systems are feasible only if the deck has the necessary pullout resistance to hold the fasteners in place. This type of system is usually not recommended for lightweight concrete, poured gypsum, or tectum decks unless toggle-bolt fasteners can be used. Most often a polyester reinforced membrane will be used for this type of system because of the higher tensile strength and higher tear resistance that can be obtained by the use of the polyester fabric.

The fully adhered system is one in which the membrane is completely glued to the substrate using an adhesive. This system is usually the most expensive method of attaching a single-ply roofing membrane. In addition, careful attention must be paid to the dimensional and thermal stability of the membrane and to the interlaminate strength of the substrate to be sure it has the capacity to physically restrain the membrane. This system is used on roofs that do not have the loading capacity for a loose-laid ballasted system and where the deck does not possess sufficient pull-out resistance for a mechanically fastened system.

With P.V.C. membranes, the two primary methods for field seaming the individual sheets together into a watertight roof assembly are solvent welding and heat welding. Solvent welding involves applying a solvent (usually tetrahydrofuran) on the top and bottom sheets of the membrane overlap (usually 2 - 4 inches) and then weighing down the seam until the solvent carrier evaporates. The seam is then checked with a needle probe and voids are repaired using a hot air welding tool. The seam is then caulked with a P.V.C. paste joint sealant to prevent any possible seam leakage.

Heat welding involves using an electric hot air welding tool that forces hot air (700 - 900 degrees) into the overlap of the individual sheets and physically melts the sheets into a single piece. Hot air welders are available in electrically powered self-propelled automatic machines for the majority of the seaming work and hand-held models for detail work. With either the self-propelled model or the hand-held model, the operator must pay constant attention to the quality of the weld as temperature and humidity will have an effect on the rate at which the membrane can be seamed together.

When choosing a P.V.C. membrane, the owner or designer should carefully study the literature, specifications and details of each of the manufacturers being considered for use. The available material should be studied for how thorough the manufacturer is on installation procedures. The different material literature should be compared and preference should be given to those products that have the most complete specifications and material information available.

Summary

P.V.C. as a roofing product has been in use for 20 years. Its properties make it a good choice as a roofing membrane. These properties are: fire resistance, ozone resistance, and strength. Its properties and weathering ability are completely dependent on its formulation and the nature of the plasticizers selected. Therefore, only products with a good record of performance over a several-year period should be considered for use.

CHLORINATED POLYETHYLENE (CPE)

The CPE resin falls between polyethylene (PE) and polyvinyl chloride (PVC). The addition of chlorine to the hydrocarbon backbone of polyethylene improves the fire retardancy of polyethylene and also provides polarity to the polymer chain. This chlorination of the polyethylene is random and therefore makes the C.P.E. material potentially more stable than P.V.C.

The degree of polarity of the plastic material indicates if it will be solvent weldable or not. A low substitution of chlorine will necessitate a heat sealing procedure similar to polyethylene. A higher substitution of chlorine will enable the solvent bonding procedure similar to P.V.C. Products containing up to 30% chlorine by weight are softer, more rubbery and more soluble than polyethylene because of loss of crystallinity. In products with 40% - 50% chlorine, the polymer becomes harder with higher softening temperatures. It is possible to have as much as 73% chlorine by weight in the polymer chain. For comparison, P.V.C. chlorine content is 56%.

At this time C.P.E. has not acquired widespread use as a roofing material, even though several companies have been producing a variety of reinforced and nonreinforced products for the last few years. While it displays some excellent properties for use as a roofing material, its cost is relatively high.

C.P.E. can be made to have the desirable properties of P.V.C. but without the need for plasticizers to give the material its elastic quality. Yet like P.V.C. and other calendered products, it is susceptible to shrinkage when produced in a non-reinforced material. Like P.V.C. products, this shrinkage can be significantly reduced by the use of appropriate reinforcing, most commonly some type of polyester scrim.

C.P.E. does not contain plasticizers because the introduction of chlorine to polyethylene makes the material more rubbery. Chlorinated polyethylene does however contain stabilizers and fillers. An interesting property of C.P.E. is its ability to accept as much as 300 to 400 per cent fillers. The stabilizers recommended for use with C.P.E. are similar to those used for stabilizing P.V.C. material, although their effectiveness is not directly comparable.

Chlorinated polyethylene as a material has excellent resistance to alcohols, alkalis, acids, and abrasion. C.P.E. possesses good resistance to weather, ozone, U.V., and oxidation. It also has good color stability, which is important for aesthetic reasons only. Its disadvantages are poor resistance to aromatic and oxygenated solvents as well as high cost when compared to other materials used for single-ply membranes.

C.P.E. has many advantages for use as a single-ply roofing material. It is tough, fire resistant, chemical resistant, and the seams can be either solvent or heat welded. If properly manufactured and installed, it can be an excellent, though rather expensive, roofing material. Because of shrinkage and thermal movement, it is better suited as a mechanically fastened or loose-laid material. One manufacturer, however, produces a fleeced back material that is meant to be adhered to the substrate using either asphalt or a cold applied adhesive as the bonding agent. If adhered, the substrate must possess sufficient interlaminate strength to control the shrinkage and thermal movement of the membrane without failing. This item should be reviewed carefully before installation of any fully adhered system.

As a loose-laid membrane, chlorinated polyethylene does not appear cost effective when compared to other materials, such as E.P.D.M. or P.V.C., unless there are chemicals present in the environment that would be detrimental to the other systems. Since C.P.E. has excellent resistance to most chemicals, the extra cost of the C.P.E. membrane could be justified if harmful chemicals were present in the rooftop environment.

The mechanically fastened system seems to have the best potential for the C.P.E. materials now available. The excellent weathering and fire resistive qualities of the material can best be exploited in an exposed application. With proper reinforcement, C.P.E. can have sufficient tensile strength and elongation to be used in a mechanically attached system, and unlike in an adhered system, a relatively small amount of membrane shrinkage and thermal movement does not present a problem.

For the most part, chlorinated polyethylene has not had widespread use in this country. It has been in use for about five years, and only now is beginning to be used in all sections of the country. Like all single-ply roofing products, a successful track record is mandatory before it can be considered for use. Manufacturers should be required to submit such data as date of earliest general usage (not test roofs), what amount of their material has been successfully used (hpefully at least 5 million square feet), and a list of client references.

If careful checking of the material indicates that it has sufficient usage in climates similar to your location and its performance has been successful, it can be considered for use. The owner or designer must be sure, however, that there is a local applicator with enough experience to be totally familiar with the product. As for any single-ply roofing, the application is of primary importance. With relatively little use in most parts of the country, experienced applicators will be hard to find in some areas.

Summary

C.P.E. as a material has excellent properties for use as a roofing membrane. Its biggest liabilities are high cost and relatively infrequent use in most parts of the country. It is expected that the track record of the producers of C.P.E. materials will improve over the next few years as their experience with the material increases. Due to its good chemical resistance, it would seem an excellent choice for any project where hazardous chemicals are present on the roof.

CHLOROSULFONATED POLYETHYLENE (C.S.P.E.)

Hypalon is a synthetic rubber made by Dupont. Its structure is a chlorosulfonated polyethylene that is vulcanized and cured in a manner similar to other chlorinated rubbers. Hypalon has excellent ozone resistance, light stability, heat resistance, weatherability, resistance to deterioration by corrosive chemicals, and good oil resistance. The major physical disadvantage of Hypalon when compared to other elastomeric materials is its poor ability to retract rapidly back to its original dimensions once it is stretched. It also exhibits some permanent set, i.e., it will not recover fully back to its original dimensions after the release of stress.

C.S.P.E. roofing membranes have been available, in different forms, for almost twenty years. Most of these membranes have consisted of thin sheets of partially cured Hypalon material (around .020" - .025" thick) factory applied to a mineral fiber backing (approximately .15" thick). The mineral fiber was changed from asbestos in the 1970's when use of asbestos materials became prohibited. These sheets are fully adhered to the substrate using a one-part water-based adhesive. Seaming is accomplished using a synthetic rubber solvent. Recently this system has been installed in a loose-laid ballasted application using a polyester scrim in lieu of the mineral fiber backing. Both types of sheets cure on the job site after installation when exposed to air and sunlight.

Another type of system now available is a partially cured, polyester reinforced material that can be heat welded together while it is still in a partially cured state. This system cures when it is installed on the roof, with the curing time varying, depending on the temperature and humidity at the job site. This material cures when exposed to air and sunlight so it must be kept stored in sealed opaque plastic prior to installation if it is to remain heat seamable.

If the material does not respond to hot air welding when delivered to the job site, the manufacturer has a primer which reactivates the membrane. This primer consists of a combination of solvents and C.S.P.E. that etches into the material and deposits fresh C.S.P.E. into the membrane. If this does not work or if the membrane needs to be repaired once it has cured, it can be seamed using a contact cement.

This system can only be applied either loose-laid ballasted or mechanically attached. The manufacturer does not allow this material to be fully adhered. This limits the use of this system, as some decking material does not permit the economical installation of a mechanically fastened system, and most existing structures cannot accommodate the required weight of ballast.

C.S.P.E.'s excellent weathering capability, fire resistance, and good dynamic qualities make it a good choice for a roofing material if the membrane is properly restrained by a suitable reinforcing material. Because of the poor "snap back" ability of hypalon and its tendency to display permanent set, it should not be installed in areas where a large amount of building movement is expected. Once the membrane is severely stretched, it will not return to its original shape.

Because this material can only be seamed using either solvent or hot air welding, while it is in an uncured state, it should not be used where future expansion is planned unless expansion joints can totally separate the new and old roof sections. If an old, cured membrane is modified it is necessary to use a contact adhesive which is not as strong as solvent or hot air welding.

C.S.P.E. is a fire resistant material, light in color, and expensive. To be cost effective, its best application is in an exposed (non-ballasted) roofing system where its light coloring and fire resistive nature can be best exploited. When used in a ballasted system, its color and fire resistance, which is an advantage over other single-ply roofing materials, is basically nullified when comparing it to other, less expensive, roofing membranes.

Due to its high cost, Hypalon is normally manufactured in very thin sheets. While C.S.P.E. is a very tough material, this report believes that a minimum thickness of 40 mils is necessary to prevent accidental puncturing and to withstand normal rooftop traffic. Some sheets are manufactured at less than this thickness and are therefore not recommended.

Summary

C.S.P.E. or Hypalon is a tough, fire-resistant material which can be applied in a partially cured state that cures after installation. Unlike other elastomeric membranes, C.S.P.E. does not display "snap back" qualities and should not be used in areas of excessive building movement. It should be reinforced to prevent creep and limit expansion. It is an expensive material which is light in color and most cost effective when used in an exposed application.

ETHYLENE PROPYLENE DIENE MONOMER (EPDM)

The EPDM's are elastomeric terpolymers of ethylene, propylene, and a diene monomer. A variety of diene monomers can be used with ethylidiene norbornene, 1.4 hexadiene, and dicyclopetadiene being the most widely used. Since one double bond of the diene is lost when the diene enters the polymers and the second double bond which remains is not in the polymer but pendant and external to it, the outstanding resistance of a saturated elastomer is obtained, i.e., the degrading attack in natural rubbers and many synthetic ones by heat, light, oxygen, and ozone are inherently absent in E.P.D.M. Generally, from 4 to 5% by weight of diene is employed, however, as much as 10% is incorporated into some E.P.D.M.

A major advantage of E.P.D.M. is its operating temperature range. The brittleness point of E.P.D.M. is very low (-75 degrees F) and its top operating temperature is 300 degrees to 350 degrees F. A major disadvantage in the application of E.P.D.M. compounds are that they are nontacky. This sometimes causes problems in instances where it is necessary to join two stacks as in the lap seams. Those problems can be avoided somewhat by the addition of a tackifier.

The major disadvantage of E.P.D.M. rubbers are their flammability. Flame retardants can be included in the rubber compounding. A reactive flame retardant that has been used used E.P.D.M. is diacrylate adduct of tetrabromo bisphenol A. The advantage of a reactive flame retardant is that it is physically bound into the polymer backbone and can not be lost by leaching or bleeding away.

E.P.D.M. has qualities which make it an excellent choice for single-ply roofing. It has excellent tensile strength, elongation capacity, has good ozone resistance, tear resistance, and low temperature flexibility. Basically, E.P.D.M. has outstanding weathering characteristics that are very desirable in a single-ply product. It is a versatile product that can be used in many different roofing applications and in various climatic conditions. Sheet sizes can be varied from four feet wide to one hundred feet wide and up to two hundred feet in length.

The major disadvantages of E.P.D.M. are that the membranes presently marketed are not fire resistant, will degrade rapidly when exposed to compressor oils, and have relatively weak lap seams. While these are serious problems that require consideration, they are not insurmountable if the material is used within its limitations.

If E.P.D.M. is used in a ballasted roof assembly, it can achieve a Class A rating, as the rock ballast can easily protect the membrane. If E.P.D.M. is to be used exposed, ie. in either a mechanically attached or adhered system, some manufacturers offer a sand and hypalon coating that will provide protection for the material. Unfortunately, this coating will have to be reapplied every five to eight years and it is not covered by the manufacturer's material warranty. The hypalon coating has a tendency to delaminate in areas where there is ponded water.

Some manufacturers are coming out with what they say will be fire resistant materials that will require no coatings. These new fire resistant materials should be available within a year. This development will be a major improvement for E.P.D.M. membranes if the fire retardancy can be achieved without changing the desirable qualities that are normally associated with the material. These new products will have to be monitored to see if the weathering ability of the material has been compromised by the fire retardent additives.

A problem normally associated with E.P.D.M. is the strength of the lap joints. This has traditionally been the weak point in E.P.D.M. systems, normal lap peel strength being 2 - 4 lbs. per lineal foot. This is far below the strength that can be achieved with other materials that solvent or heat weld their lap joints. Recent developments in adhesives by several manufacturers are greatly increasing the seaming strength of their systems. Peel - pull strengths as high as 18 lbs. per lineal foot have been reported. This is four to six times greater than possible with the adhesives previously used. It is anticipated that other manufacturers will soon develop methods to increase the strength of their lap joints out of necessity to improve their product.

One method now available for use with most E.P.D.M. membranes is the use of a chemical primer manufactured by the Lord Chemical Products Corporation. According to the manufacturer, this primer can greatly increase the seaming strength of many of the E.P.D.M. membranes now on the market. The success of this primer on a particular membrane depends on the surface texture and the blending of the different polymers, oils, and fillers used in its manufacturer. As the various manufacturers all produce their membranes by different formulas the primer does not produce uniform results on all sheets. The primer manufacturer and the membrane supplier should be consulted before a decision to use this product is made.

The disadvantage of this chemical primer is that it adds an extra step to the installation procedure. When using this primer, it is still necessary to clean the laps with a solvent wash prior to applying the primer. After this is done, the splicing adhesive can be applied to the splice area as directed by the manufacturer. This extra step will undoubtedly take additional time and therefore add additional cost. The cost will vary according to the size of the sheet used but should be minimal, usually around 2 cents a square foot. This is a small price to pay for additional seaming strength.

Another method of joining E.P.D.M. membrane is by the use of various types of tapes instead of liquid adhesives. The advantage of this type of system would be ease of application and the reduction of workman error in applying too much or too little adhesive. The type of tapes now used are butyl, gum, and synthetic rubber pressure sensitive tape.

Under the right environmental conditions most of the tapes now in use can produce a seam far stronger than the common neoprene based adhesive used throughout the E.P.D.M. industry. The butyl and gum tapes used in some systems have difficulties in field installations. It seems that these tapes have a narrow temperature range of between 40 degrees F. to 80 degrees F. for proper installation. These tapes are also subject to affect by high levels of humidity and dust contamination. If at the time of application the humidity is too high or if it is windy and there is a lot of dust in the air, the tapes have a tendency to fail. These problems with installation have kept the tape seaming systems from widespread use with E.P.D.M. membranes. This is disappointing since these tapes can provide much stronger seams than with a liquid adhesive. Because of field installation problems butyl and gum tapes are not recommended for use by this report.

A recent development is the marketing of a synthetic rubber pressure sensitive tape. This tape, according to the manufacturer, can be applied at temperatures as low as 20 degrees F. and as high as 100 degrees F, and can be applied under field conditions without any adverse effects. The peel resistance of the seams made with this tape (around 24 psi) are stronger than with any liquid adhesive now available. Though this value is not as high as with other tape systems, hopefully it can be applied under more adverse conditions. While this tape system is too new to be able to make a judgement on its performance, initial reports on its use have been favorable.

In terms of application E.P.D.M. can be applied either loose laid ballasted, mechanically attached, or fully adhered. The loose laid ballasted method is the most common and usually the most cost effective. The mechanically attached method is relatively new with most manufacturers, but has been gaining acceptance for use where ballasting cannot be used. The fully adhered method is the most expensive and is the most difficult to install.

The loose laid ballasted application has significant advantages for an E.P.D.M. membrane system. As mentioned earlier in this section, ballasting provides fire resistance for the membrane. It also provides protection from falling objects, hail, and some vandalism. For even more shielding a protected membrane system can be used where a high incidence of vandalism is anticipated. Another advantage of the ballasted system is that more than any other attachment method, it allows the membrane to expand and contract as a single piece. Since E.P.D.M. displays a comparatively large amount of thermal movement, this allows the material to expand and contract as the temperature fluctuates.

The biggest problem associated with ballasted systems is the extra weight necessary for this type of installation. Another problem is that if the membrane is somehow punctured or a seam begins to fail, the ballast must be carefully removed to find the leak. Since the membrane is loose laid, water can travel under the membrane a long way before entering the building. This can make finding the source of the leak difficult and time consuming. In areas where high velocity winds are common, some problems have developed with the ballast being swept off the corners of the roof. Often this problem can be eliminated by using concrete pavers at the roof perimeter instead of small stones.

The mechanically attached systems are rapidly coming into use for roofs that cannot support the load of ballast. E.P.D.M. has sufficient tensile strength and elongation with recovery to function in this type of system. The material can still thermally expand and contract as it requires, but only between fasteners. The seaming strength is very important as more force is applied at the lap joints with this type of installation than with the other systems. As the seaming strength is normally the weakest point of an E.P.D.M. System, the systems should be held down at all lap joints to prevent separation.

The uplift resistance of this type of system is dependent on the fastener spacing and the pullout strength of the fastener from the decking material. The pullout strength of a fastener depends on the decking material, its composition and thickness. For instance, a typical screw-type fastener's pullout strength from a steel deck can vary by as much as 14.5% depending on whether it is a 20 gauge deck or 22 gauge deck. The pullout strength of the same fastener from 3/4" A.C. exterior plywood (422 lbs.) is slightly less than from a 22 gauge deck. The Owner or Designer should be sure that the decking material has sufficient strength to meet the manufacturer's requirements. If the decking has very little pullout resistance, alternate fasteners, such as toggle-bolts can be used. This is usually done on lightweight concrete or poured gypsum roof decks. The installation of toggle-bolts or concrete expansion anchors can become cost prohibitive. If such fasteners are needed it may be advisable to use another fastening method. Another problem with toggle-bolts is that provision must be made to prevent the bolt from backing out.

With the mechanically fastened system, the membrane is left exposed. With an E.P.D.M. system, this means a non-fire-resistant roof unless it is covered with a sand and hypalon coating. This is a maintenance item for the owner and should be recognized as such. The coating will have to be replaced every five to eight years and in ponded areas the coating will deteriorate even faster. The owner should inspect the coating every year as part of a roof maintenance program and repair any deteriorated areas.

The fully adhered system is the least common method of attachment as well as the most expensive. It is also the most difficult to install and requires the most attention to the quality of the substrate of all of the attachment systems. As E.P.D.M. displays a high degree of thermal movement, the substrate must possess sufficient shear strength to restrain the movement of the membrane. In addition, the porousity of the substrate material must be taken into consideration when applying the adhesive. The more porous a material, the more adhesive will be needed to properly bond the material.

With an unreinforced elastomeric material, such as most E.P.D.M.s, the elastic qualities of the membrane may cause the sheet to become unadhered due to peeling action during high wind conditions. This is possible if the membrane is adhered to an insulation with low shear strength and a small area of the roof exposed to wind uplift forces is unadhered. This area may become unadhered due to a variety of reasons including: workman error, failure of the insulation due to the effect of moisture on the surface of the insulation at the time of installation, or failure of the insulation due to shearing forces produced by the thermal movement of the membrane. If even a small portion of the membrane becomes unadhered, a failure will tend to propagate whenever high wind conditions are present. Once the uplift forces diminish however, the membrane should lay back down on the roof deck. This will make this type of failure difficult to detect until the membrane pulls loose from either the building perimeter or roof penetrations and water can then enter the building. By this time the failure can be quite large and costly to repair.

This report does not recommend adhering any unreinforced elastomeric material due to the possibility of this type of failure. If it is absolutely essential to adhere an elastomeric material, it should only be done with the utmost caution. It is recommended that the Owner demand a letter from the membrane manufacturer guaranteeing that the roof system will resist an uplift force of 90 p.s.f. This guaranty should include the insulation, adhesives, fasteners, as well as the E.P.D.M. membrane. For most buildings a 90 p.s.f. uplift resistance for the roofing system will be sufficient to withstand all but the most severe wind conditions. This will vary according to local wind conditions, height of the building, parapets, surrounding terrain, etc. The 90 p.s.f. uplift resistance should be regarded only as a guideline. The individual requirements of each building should be investigated before any adhered roofing system is installed.

One item that should be mentioned is that E.P.D.M. membranes, like other calendered materials, have a normal shrinkage rate of about 2%. For this reason it is necessary to mechanically fasten the material at the perimeter and at all rooftop penetrations. This is typically done by using pressure treated wood nailers attached to the roof deck and then fastening the membrane to the wood nailers. Care should be taken to be sure that the nailers are anchored securely enough to resist the anticipated wind uplift force.

Summary

E.P.D.M. has excellent weathering qualities, elongation capacity and low temperature flexibility. It has poor resistance to oils, is quite flammable, and is difficult to seam. Its best application is in a ballasted roof system where the ballast can provide fire resistance for the membrane. The materials natural tendancy to stretch and its high degree of thermal movement make adhering this material very difficult.

POLYCHLOROPRENE (NEOPRENE)

Neoprenes were the first synthetic rubbers developed in the United States where they are primarily known for their oil resistance. Neoprene rubbers are resistant to oxidative degradation and their weathering abilities and ozone resistance are quite good. Because of the chlorine in the polymer, neoprenes are normally self-extinguishing and resist combustion to a greater degree than non-halogen bearing polymers. Due to the process by which chlorine is prepared, neoprene is more costly than other elastomeric materials. This extra cost is the primary reason why neoprenes are used only where their superior properties warrant this higher price.

Neoprene rubber has been in use in this country as a roofing product since about 1960. It was first used as a specialty product on roofs where shape and aesthetics dictated an alternative to built-up roofing. Because of its resistance to oils and its inherent fire resistance, neoprene is sometimes used on roofs around air handling units and where a fire resistant roofing is required. Neoprene roof membranes can be made in either a weathering grade that does not require any coating or a nonweathering grade that requires a hypalon coating for U.V. protection. The weathering grade cannot be coated without staining of the hypalon, which is aesthetically unattractive.

Neoprene membranes can be applied either loose-laid ballasted, mechanically attached, or fully adhered. The lap seams are joined using a neoprene based contact adhesive. Application techniques are similar to those used with E.P.D.M. membranes, with some companies using the same specifications for both products. Neoprene does not have quite as much tensile strength, elongation capacity, or ozone resistance as E.P.D.M. membranes. Additionally neoprene does not perform quite as well under stress as E.P.D.M. materials.

The contact adhesive normally used with both neoprene and E.P.D.M. membranes is a neoprene based adhesive. For this reason, neoprene membranes have greater seaming strength than is found with E.P.D.M. Membranes and lap seaming strength is not normally an issue with neoprene systems.

MODIFIED BITUMEN

Modified bitumen is a catch-all phrase used to describe a variety of products that involve the use of bituminous materials blended with a wide range of possible modifiers. The bitumen used can be derived from either the processing of petroleum (called asphalt) or residues produced via destructive distillation of coal (called coal tar pitch). Modified bitumen products using asphalt are by far the most common, though some membranes using coal tar pitch are available.

While most materials used in single-ply roofing consist of well-defined monomers and follow well defined behavior patterns, bitumen consists of a mixture of hydrocarbons that are not well defined. A bitumen is polymeric; however, its chemical nature is dependent on its source. Refineries normally are processing crudes from all available sources. A bitumen (asphalt) may have the same physical properties as an asphalt delivered earlier, but does not necessarily have the same chemical constituents. These chemically different asphalts may perform very differently in field application.

The properties that are usually used to define the modified bitumen products are based on mechanical testing and are not co-related to such properties as weathering. While mechanical testing such as tensile strength, elongation, and dimensional stability are important for determining the appropriate usage for the material, they give no indication of the long-term durability of the membrane. Since the weathering ability of the bitumen varies from source to source, the weathering property of the finished product also should vary.

Modified bitumens are generally reinforced with either a fiberglas mat, polyester scrim, mineral fillers, polyethylene sheet, or a combination of two or more of the previously mentioned items. These reinforcement materials help lend strength as well as dimensional stability to the sheet. The reinforcement of the modified bitumens give the material its tensile strength and keep the material from flowing at high temperatures.

The two most common modifiers are styrene-butadiene-styrene (SBS) and Atactic Polypropylene (APP). These materials are blended into the bitumen to lend them elastic qualities far in excess of a normal bitumenous material. Both of these materials will flow at high temperatures and therefore lend themselves for use with heat welded systems. Under normal roof-top temperatures, however, they are elastomeric in nature.

SBS is an elastomer that is sensitive to ultra-violet degradation. All modified bitumens using this modifier must be protected from U.V. exposure by a top layer of either embedded granules, metallic foil, polyethylene film, or a variety of liquid applied coatings. The more permanent and to some extent flexible the coating, the better they will perform. An inflexible protective coating that splits when the material expands will not perform its function. An advantage of SBS modified bitumen is that its increased low temperature flexibility, while not good, is significantly better than bituminous built-up roofing.

Atactic polypropylene (APP), a thermoplastic material, displays much better weathering properties than SBS. Modified bitumens using APP do not require heavy protective coatings, but have reduced low temperature flexibility. This makes APP modified membranes a poor choice for climates where low temperatures fall below 20 degrees F.

Modified bitumens are often favored by roofing contractors because of their resemblance to built-up roofing. Modified bitumens are applied using a full mopping of asphalt, torched to the substrate, or are self-adhering. The construction and installation techniques for each of these systems vary, with each system having its own strengths and weaknesses.

When applied using a full mopping of hot asphalt, modified bitumen most resembles built-up roofing. The only major difference is that there is only one ply and the make-up of the sheet is much different than more traditional felts. As in built-up roofing, care must be taken to have the asphalt at the correct temperature at the point of application, and to be sure that the correct amount of asphalt is used at all times. Workmen must be careful not to walk on the sheet while the bitumen is still hot or they might squeeze the asphalt out from underneath the sheet.

In reroofing, the existing roof membrane is left in place, if the insulation is not saturated. If there is a gravel surface, it is normally broomed off. Any wet insulation must be replaced prior to new construction. A recover board is then laid in hot asphalt over the old roof surface. A fiberglass base sheet is then applied using a full mopping of hot asphalt. Like all calendered membranes, modified bitumen sheets should be unrolled and allowed to relax prior to application. The sheet is then rerolled and mopped down according to the manufacturer's instructions.

With this system, the problems normally associated with built-up roofs still exist. The need to have asphalt kettles and the associated fumes are bothersome on reroofing jobs where the building is occupied while the work is being done. The temperature restrictions that apply to built-up roofing should also be used when adhering modified bitumens. The mess that accompanies the use of hot asphalt also can be a problem if the workmen are not careful. If carefully applied, however, this method of application would seem to have significant advantages over built-up roofing. Its elongation capabilities, tensile strength, dimensional stability, and low temperature flexibility are all greater. Yet, if compared to other single-ply systems, its low temperature flexibility is not as good.

By far the most common method of applying modified bitumens is by using a torch to adhere the membrane to the substrate. Membranes designed for this type of application have a bottom side that is saturated with bitumen that is activated by heat. This causes the bitumen to flow out of the sheet and bond the membrane to the substrate. Careful heating of the bottom surface is required to properly adhere this type of surface. If too little heat is applied, not enough bitumen is supplied; too much heat and the membrane can be scorched with all the bitumen burned off. This type of membrane should also be unrolled and allowed to relax, then rerolled and immediately applied.

The installation of this type of system is normally accomplished using either a hand-held torch or a wheeled machine that uses several flame heads to evenly heat the bottom of the membrane. The roll of membrane must be pushed into a small wave of adhesive that comes out of the membrane as it is properly heated. If a hand-held torch is used, the rolled membrane is pushed ahead of the roofer, who heats the membrane using a long-necked propane torch moved carefully across the bottom of the sheet to achieve the proper flow of bitumen. The edge laps are then sealed using a torch and trowel to effect a neat feathered seam.

If a wheeled machine is used, the roofer torches down the starting edge and then pulls the machine across the roof, regulating the amount of flame necessary to properly apply the membrane. The machine holds and unrolls the membrane while multiple torch heads provide a quicker, more even heating of the membrane back than possible with a hand-held torch. The lap seams are finished with a hand-held torch and trowel.

Extreme caution should be used when using an open flame to install any roofing system. Care must be taken to avoid injury to workmen and damage to the building. Any insulation used on this type of insulation should be non-flammable. There have been reports of fires occurring at buildings where this type of roof has been installed. Though many roofs have been installed with no problem, some danger cannot be avoided, however, when an open flame is present for the duration of the job. This fact alone should make this type of installation technique unacceptable to many owners.

The third type of installation technique, a self-adhering membrane, is the least common. With this method, the membrane has a rubberized asphalt backing that is the ahhesive. This material is quite tacky and when the release paper is pulled off, it attaches itself to the substrate.

With this system, surface preparation is very important. As with all modified bitumens, the surface should be clean, dry, with all fishmouths and blisters cut out. In addition, this system requires that the substrate be primed to present a dust-free surface. With this system, any dirt, dust, or moisture will prevent the system from properly adhering.

After the membrane is applied, the membrane must be coated, as the top membrane layer is not U.V. resistant. This top layer will deteriorate when exposed to weather, yet it is this layer which gives the material its strength. While the rubberized asphalt has very good elongation capacity, it has low tensile strength. The polyethylene has very good tensile strength and elongation capacity, but is subject to high thermal movement. This means that the material has a tendency to expand or contract due to temperature changes. For a totally adhered system, this means that unless the substrate has sufficient interlaminate strength, the membrane movement might cause the substrate to delaminate.

A system has been recently developed that uses a different top layer material that is resistant to weathering and does not require any protective coating. This material is new and has not been on the market long enough to prove itself in field use. Not requiring any protective top coating is an improvement, but not enough if the thermal movement has not been improved.

In general, modified bitumens have superior performance characteristics to the traditional built-up roof. They have much greater tensile strength, elongation capacity, and resistance to flow than B.U.R.'s. They have greater low temperature flexibility than a built-up roof (but less than other types of single-ply materials). Most contractors are more comfortable switching from B.U.R. to modified bitumen than to other types of single-ply materials because of the similarity in materials and installation techniques. Modified bitumen is usually less expensive and is cheaper to flash in the penetrations than other single-ply systems.

The use of modified bitumens is limited, however, by its low temperature flexibility, elongation capacity, and weathering ability. While modified bitumens generally out-perform built-up roofing, they do not perform as well in most applications as other single-ply materials. The fire resistance of modified bitumens depend solely on their top coating; the material itself is not fire resistant. On a reroofing project, if any moisture is trapped under the membrane, a modified bitumen will blister. The poor low temperature flexibility of the material has already been discussed, but this also prevents applying most modified bitumens in temperatures below 40 degrees F. due to the stiffening of the material.

Due to safety reasons, the use of torch applied systems is not recommended by this report. It is not advisable to allow an open flame near flammable objects, such as most insulation boards. The danger of a fire occurring on a project, especially at an occupied building, is too great to justify the use of such a system as a general method of installation. There are many safer alternatives that can be used to apply a new roofing membrane.

Summary

Modified bitumens have superior physical properties when compared to built-up roofing. The similarity of the systems make it easy for the roofing contractor to switch over from using B.U.R.'s to installing a modified bitumen. Like B.U.R.'s, the weathering characteristics of the modified bitumen can vary due to the different chemical constituents of various bitumen sources. Many modified bitumens (those modified with SBS) require a top coating as they are not U.V. resistant. Modified bitumens do not have the superior low temperature flexibility, weathering characteristics, and elongation capacity of most other single-ply materials. Modified bitumens should only be considered where initial cost and not long-term performance is the most important factor.

SELECTION

- Introduction
- Criteria for use Selection
- Criteria Chart
- Material Selection Tables
- Temperature Zones

INTRODUCTION

This section of the report pertains to the specific criteria which must be evaluated in order to make a selection of a membrane system for a particular project. Included in this section are a description of general criteria for selecting a single-ply system and a short evaluation of each of the major material groups. Following this, there are general outlines for the establishment of important physical requirements of a single-ply membrane. These requirements are based on the type of installation, size of roof, ambeint temperature range at the job site, and other criteria. These are to be used in conjunction with the material selection tables which are to establish the quality of a membrane in comparison to other membranes in the same material group.

At the end of this section, there are reference tables on different material groups. These tables were assembled from the data now available. These tables are incomplete as there is not much testing data available for most of the membranes now on the market. It is hoped that this will change as industry-wide performance criteria is established, and the single-ply industry matures.

The test data that is listed in this section is what is now deemed relevant through the sources that we have employed. Continuing studies by various industry groups for the establishment of more accurate testing are now ongoing. These groups should be watched closely as they should develop better guidelines than those with which we now have to work with.

Included for quick reference at the end of this section is a map indicating the major temperature zones of the continental United States as well as comparison charts on low temperature flexibility, elongation, and tensile strength of the major material groups.

CRITERIA FOR SELECTION OF A SINGLE-PLY ROOFING SYSTEM

The number of different single-ply materials and roofing systems now available for use can make selection of a proper material very confusing to most owners or designers. It should be stated that there is no one perfect material or system that will work in all situations. Each project should be evaluated individually and a system selected that will meet the requirements of that particular job.

When considering the selection of a single-ply roofing system, the prudent owner or designer should consider the following:

(a) material durability in similar usage
(b) climatic conditions at project site
(c) structural capacity of roof
(d) code and insurance requirements
(e) cost
(f) building usage
(g) roof usage
(h) drainage
(i) decking material
(j) owner's preference
(k) warranty
(l) access to roof during construction
(m) local weather conditions during application

The ability of the material to remain weather-proof is of primary importance. The past performance of the material(s) in similar climates and usage (method of attachment, size of roof, roof top environment, etc.) is the best criteria for selecting a material. Other factors such as material characteristics and quality control should also be considered before any decision is made.

The climatic conditions at the project site should be studied. Different areas of the country have different requirements put on the roofing system. U.V. exposure, low temperature flexibility, wind uplift requirements, and ozone resistance will all vary depending on where the project is located. Local environmental concerns, such as pollution or acid rain, must also be taken into consideration.

The structural capacity of the roof to support an additional load is important during reroofing projects where a ballasted system is under consideration. The local code requirements for snow and live loading should be reviewed to be sure that the structure meets current standards with the additional weight of the required ballast. If the structure cannot carry the extra weight of the ballast, then an alternate system must be considered.

Most building codes will require a certain amount of fire resistance on some classes of buildings. If the building being roofed requires that a fire resistant assembly be used, this may disallow several materials that might otherwise be considered. It is advisable that only fire resistant assemblies be used, even if not required by local building codes, strictly from a safety standpoint.

Some insurance companies will require, or at least recommend, that only fire resistant assemblies be used. The factory mutual ratings of roofing materials are the best example of classifying and encouraging the use of fire resistant assemblies in single-ply materials. Building owners are advised to check with their insurance company before installing any new roofing membrane to see how it will affect their insurance coverage.

The use to which the building is being put will normally not affect the selection of the roofing system, unless the building is being used for either cold storage, laboratory use, food preparation, or some types of manufacturing. Cold storage facilities will prevent the use of mechanically fastened systems as well as requiring the use of a vapor barrier. Some manufacturers have special construction details when using their membrane systems above a freezer building. If so, they should be strictly followed. If no such instructions are part of the manufacturer's literature, written instructions and approval should be asked for and received before proceeding with the project.

Laboratory buildings and some manufacturing facilities often produce many types of chemical residues that find their way to the roof via exhaust hoods. Food preparation facilities such as restaurants, dormitories, etc., will often have an accumulation of animal fats on the roof near any exhaust fans. These chemicals and animal fats have a detrimental effect on many single-ply products. The material manufacturers should be consulted to be sure that the membrane systems being considered are usable on the facility in question. If there are any questions as to appropriate usage, it is advisable to demand written approval from an authorized agent of the company.

While evaluating the different roofing systems, one must consider the cost difference between the various systems. While this report does not advocate using a material solely because of cost, we do recommend using cost effective systems. Wherever possible, the cost of the system should be the least important item when comparing roofing systems. This, however, is rarely possible in a world of tight budgets and ever increasing costs.

One must compare the initial cost of the system with its performance record, life expectancy, and desirable properties. The designer or owner should always select materials and systems that are appropriate for the intended use, but normally more than one type of membrane will suffice. The designer or owner should be certain that the quality of the job does not suffer in the process of meeting a budget.

Normally a roof is not used for any other purpose than to keep the weather out and to provide an out-of-the-way storage for mechanical units. Occasionally there are those buildings where the roof, or part of the roof, is used for storage, as a sidewalk, or some other purpose not normally associated with a roof. These roofs present special problems that have to be looked at individually. Most single-ply membranes are not intended to function as a walking surface. It is advised that the owner or designer not try to force a membrane into a function for which it was never intended. It is better to protect the membrane by providing a separate walking surface and depend on the roofing only for water-proofing purposes.

While some membrane manufacturers state that ponded water does not affect their systems, it is always advisable to drain as much water off the roof as possible within as short a time as can be arranged. Ponded water can not only overload the structural capacity of the building, but can actually cause damage to some membranes. On new construction, wherever possible, 1/4" slope to drain is preferred, but 1/8" slope to drain is acceptable. For reroofing projects, it is wishful thinking to specify a minimum slope as some roofs will not accommodate any tapered insulation.

Where a mechanically fastened system is being considered, the material composition of the deck is important in relation to cost of installation and uplift resistance. Some types of roof decks such as lightweight concrete or gypsum do not provide sufficient pullout resistance for screw-type fasteners. Toggle-bolt fasteners are available for use with these types of decks, but if the underside of the deck is exposed this may be aesthetically unacceptable. If toggle-bolt fasteners are used, a chemical agent should be used to keep the toggle-wing from loosening over a period of time due to the dynamic action of the roof. As an alternate, a physical device, such as a lock-nut, can be used to prevent the toggle-wing from moving.

For steel decking, the gauge of the material should be known to figure the pull-out resistance of screw-type fasteners. The condition of the deck should also be investigated to determine whether it should be replaced. If this is not possible before construction is begun, the owner should be made aware that if deteriorated decking is found, it will have to be replaced before other roofing work can commence. A contingency in the budget should be allowed for such a possibility.

When a fully adhered system is being considered, the sheer strength of the insulation the membrane is being adhered to is of the utmost importance. Insufficient sheer strength capacity in the insulation may cuase it to delaminate when wind uplift forces are exerted on the roof surface. Care must also be taken to be sure that the insulation is securely fastened to the deck so that it does not pull up from the deck under high wind conditions. Adhering the insulation in a full layer of hot asphalt is not recommended if mechanical attachment is feasible. On buildings where mechanical attachment is not easily accomplished, mechanical fastening of the insulation at the perimater is urged if at all possible.

Sometimes an owner will develop a preference for a type of roofing material of a particular manufacturer. Such a preference should be acknowledged and accommodated wherever possible. The owner should be made aware of any deficiencies in the preferred system, and that the same roofing material is not applicable to all situations. While some material systems are more flexible than others, no material can be used in all possible situations.

If a manufacturer's warranty is to be used, then the owner should study the different system warranties carefully. Total roofing system warranties that cover all materials needed to install the system; such as insulation, fasteners, adhesives, membrane, etc., are preferable to warranties that cover only the membrane. The owner should be sure that both materials and labor are covered, as the cost of labor normally far exceeds the material cost.

Another item that should be considered is access to the roof during construction. If the roof is not easily accessible, a system that uses the least material and is the easiest to transport may be the most cost effective. An extremely high roof or one where the access is restricted may not accommodate a ballasted roof system even if all other factors are favorable. This can be strictly related to the cost of transporting the ballast to the roof, or spreasing it over a building where the roof is comprised of many different levels. These conditions can also limit the size of the individual sheets that can be easily transported to the roof.

The probable weather conditions at the job site during the time of apaplication are usually determined by the local climate and the time of year when the roofing work is to be done. If the work can be accomplished during mild weather almost any system can be considered. Some work must be done at less than ideal times of the year while some areas of the country experience high winds and other inclement weather throughout the year. If this is the case, then certain types of systems will be more difficult to install than they would otherwise be under more favorable conditions.

Membrane systems that use large sheets can be extremely difficult to install during even moderately windy conditions. If a large sheet is blown about by the wind, it can exert a powerful force at the membrane edge. During installation, this can be quite dangerous to those workmen who are installing the system. If such conditions are expected, the size of the sheet can be limited to avoid complications.

Membrane systems that use adhesives will be affected by temperature and humidity conditions at time of application. Installation should be discouraged when temperatures fall below 40 F. Not only will most adhesives require preheating and longer drying times, but the workmanship may suffer if the workmen are uncomfortable. During periods of high humidity, adhesives will be harder to work with and take longer to dry. Any accumulation of moisture on the membrane lap joints can seriously jeopardize the integrity of the seam.

When a roofing system is being applied during cold weather, work should not be allowed while there is any frost on the roof. It is advisable to avoid trapping any moisture in the system if it is at all possible. This is especially important when using a fully adhered system, as this is the most sensitive to moisture, humidity, and temperature at the time of application.

While there may be other factors that require consideration for some projects, this selection should outline the major points that are normally important in the selection of a single-ply system. While the selection of the proper roofing system is important, it must be noted that good workmanship is required to produce a dependable roof system.

HOW TO USE THIS SECTION

The following outlines can be used in the determination of what type of attachment system can be used on a roofing project and the critical physical properties that are needed by the roofing membranes to perform under that attachment method. These outlines are by necessity general in nature and individual projects may generate additional requirements that are not covered in this section.

The first outline given is for single-ply roofing in general and not for any particular membrane or attachment method. The next outline is for a loose-laid ballasted system and protective membrane system, mechanically attached, and fully adhered systems. The material criteria given in each of these outlines are for the attachment system and not for any individual material type.

After an attachment system is chosen and the material requirements are known (use both the general roofing outline and one of the particular attachment outlines), one should then proceed to the material selection tables. These tables are set up by individual materials and list the particular testing required to determine the quality of a membrane when compared to other membranes of the same material family.

The testing requirements in each table are weighted to reflect the properties that, in the opinion of this report, are most important or least important for the performance of the material as a roofing membrane. These tables also list the percentage of the minimum standards that are displayed by the membrane being evaluated. This percentage (%) is to be multiplied by the importance factor to give the performance of the membrane being investigated in that category.

Example:

Weighted factor	Minimum	% of Minimum	
8	90% of material	(85%) = .944% x 8	= 7.55
5	9 psi	(10 psi) = 1.11% x 5	= 5.55
13			13.1

A membrane may only meet a percentage of one category but might exceed the requirements in another category. In pass/fail categories, the score is either 100% or 0%. In all other categories, the maximum allowable score is 10% greater than the weighted factor given, while the minimum score can be 0%. Therefore, if a test category has a factor of 8, the greatest possible score is 8.8, while the lowest is 0.

If a membrane meets or exceeds the test score of 90, it will function well in comparison to other materials in its material class. One then must look at the requirements needed for the particular attachment method that is to be used and pick a material that meets all of those requirements.

It is not recommended to use a membrane that meets the requirements listed under the general roofing outline and one of the attachment method outlines if that membrane does not also meet all of the requirements for its material group.

CRITERIA FOR USE SELECTION

E.P.D.M. - This material displays good tensile strength, excellent elongation, good low temperature flexibility, is relatively cheap in cost and displays excellent weatherability. Disadvantages are poor resistance to oils and fire as well as high thermal movement.

USES: Best used in a ballasted application as this provides fire protection and allows for both shrinkage and thermal movement. Because of its excellent elastic nature, this material should function well on any size roof. This material can also be used in a mechanically fastened system, but the membrane will have poor fire resistance unless coated with a sand and hypalon coating. Adhering E.P.D.M. to insulation material is not recommended.

NEOPRENE - Similar to E.P.D.M. in many respects, but also displays good resistance to both oils and fire. Neoprene is more expensive than E.P.D.M. and therefore not in as widespread use.

USES: Because of the cost of this material, it is normally used only where good resistance to oils and or fire is necessary. Because of its elastomeric nature, it is not recommended to adhere neoprene to insulation materials that have low shear strength.

CHLOROSULFONATED POLYETHYLENE (HYPALON) - This is a synthetic rubber made by Du Pont. It is now marketed as a partially vulcanized membrane that can be heat welded and as partially vulcanized material which must be seamed using solvents. It has excellent weathering characteristics, good resistance to oils, corrosive chemicals, fire, and good low temperature flexibility. While hypalon has good tensile strength and elongation capacity, it has poor ability to "snap" back to its original shape once it is elongated. To prevent excessive shrinkage and thermal movement it must be reinforced, which is commonly done by adhering the material to a mineral fiber backing or using a polyester reinforcement. The material is quite expensive and therefore is normally manufactured in very thin sheets.

USES: This report does not recommend using any single-ply material less than .040" in thickness. The mineral fiber backed materials are all thinner than this and therefore should not be used in any application. The reinforced membrane is of adequate thickness but has not been on the market for a sufficient time period to judge its effectiveness. If used, however, it should be limited to ballasted and mechanically attached systems. It should function well in areas where corrosive chemicals are present or there is above normal rooftop traffic.

BUTYL RUBBERS (Polyisobutylene-Co-Isoprene) - This material has much lower tensile strength than the other elastomers and displays a tendency towards cold flow. It does, however, have outstanding chemical inertness and good weathering properties.

USES: Because of its cold flow characteristics and high material cost, this report does not recommend the use of this type of system.

SILICONE RUBBERS - Displays outstanding weathering abilities and a very broad service temperature range. Silicone rubbers have inferior tensile strength, elongation capacity, tear and abrasion resistance than other elastomeric materials.

USES: Because of its inferior dynamic properties, this report does not recommend the use of this material for a single-ply membrane. Except for its poor abrasion resistance, it would make an excellent coating.

POLYETHYLENE (PE) - This material can be manufactured to be very tough, is resistant to chemical degradation and has good dynamic properties. Polyethelene is quite flammable and difficult to bond to, therefore it must be seamed together by heat welding.

USES: This system type is not recommended for use because of the limited exposure history and its flammability.

POLYVINYL CHLORIDE (PVC) - This material has good tensile strength and elongation capacity. It can be made to be very tough, dirt resistant, and fire resistant. Degradation of the material is through plasticizer loss which can be slowed down but never completely halted. The rate of plasticizer loss is wholly dependent on the blend of P.V.C. resins, plasticizers, stabilizers, and fillers used in the compounding of the material.

USES: This system type works well ballasted, mechanically attached, and adhered. If adhered, the thermal movement of the material must be minimal and the insulation must possess sufficient material to resist the expected wind uplift forces.

CHLORINATED POLYETHYLENE (CPE) - This material has good weatherability, fire resistance, tensile strength, chemical resistance and elongation ability. Like all calendered material, it will shrink unless reinforced, and the material cost is high.

USES: This material can be ballasted, mechanically attached or fully adhered to the substrate. The physical properties of this material make it a good choice for use as a roofing membrane, but its cost makes it a non-cost-effective choice unless the chemical and fire resistance qualities of the material are needed.

MODIFIED BITUMEN - This category covers a wide variety of materials but will be described as one material as best as is possible. This material generally does not display good weathering ability and requires the use of a coating to provide U.V. and fire protection. This material has poor low temperature flexibility and poor elongation. Modified bitumens are superior to built-up roofing with greater elongation, tensile strength, and ease of application.

USES: This material can be used where roof size is limited, anticipated building movement is low and cost is an important factor. Since this material has limited low temperature flexibility, it is recommended that it not be used in areas where the low winter temperature falls below 0 degrees F. Torched down membranes are not recommended by this report.

GENERAL ROOFING OUTLINE

Project Checklist

1. If perimeter nailers are required, they should be attached to resist forces in accordance with manufacturer's instructions. (Recommended minimum - able to resist a minimum force of 150 lbs. per lineal foot in any direction.)

2. Roof structure should be analysed for dynamic movement (flexing) of the decking. This is particularly true of lightweight roof structures. This type of movement may necessitate additional fastening of the insulation (if applicable) and the membrane.

3. (Reroofing only) - Existing through wall flashing must be identified and care should be taken not to cover these up with new roof membrane.

4. (Reroofing only) - Existing coping, flashing, pitch pans, etc. should be inspected to determine if they must be replaced.

5. (Reroofing only) - Fresh air intakes on roof should be shut down (if possible) during reroofing project to prevent any fumes from entering building. Coordinate with owner.

6. (Reroofing only) - Determine condition of existing roof membrane and insulation to see if it must be replaced. All wet insulation and roofing material should be removed prior to start of any new work. Test cuts or moisture scans of roof should be made if roof has been leaking.

7. (Reroofing only) - Check condition and location of existing drains. Determine if drainage is sufficient or whether additional drains (if possible) are needed.

Material Selection

1. Low temperature flexibility - Minimum of 5 degrees Fahrenheit below record low temperature as recorded at nearest national weather service facility.

2. Chemical resistance - Identify all chemicals and oils which will be present on roof. Select roofing membranes that are resistant to degradation by these chemical contaminants.

3. Insulation should be compatible with roofing material and possess sufficient compressive strength so as not to fail under normal rooftop traffic (200 lbs. per sq. ft. - min.). If desired insulation material is incompatible with membrane, a separation board or sheet may be used. Consult with membrane manufacturer for details.

LOOSE-LAID BALLASTED MEMBRANE SYSTEM

Ballasted roof assembly preferred wherever possible. This type of system is normally most cost effective, has enjoyed good success in this country, and ballast provides protection for membrane.

CHECKLIST FOR USE OF BALLASTED ROOF SYSTEM

1. Does roof structure have capacity to safely carry ballast load (10 p.s.f. to 12 p.s.f.)?

2. Does roof slope within allowable limits for the application of ballast (0" - 2" per foot)?

3. Is roof accessible for the transportation of the ballast to the roof?

4. Is building located in an area of extremely high winds where stone ballasting is unadvisable? (Does area regularly experience winds in excess of 70 m.p.h.?)

MATERIAL SELECTION FOR BALLASTED ROOF SYSTEM

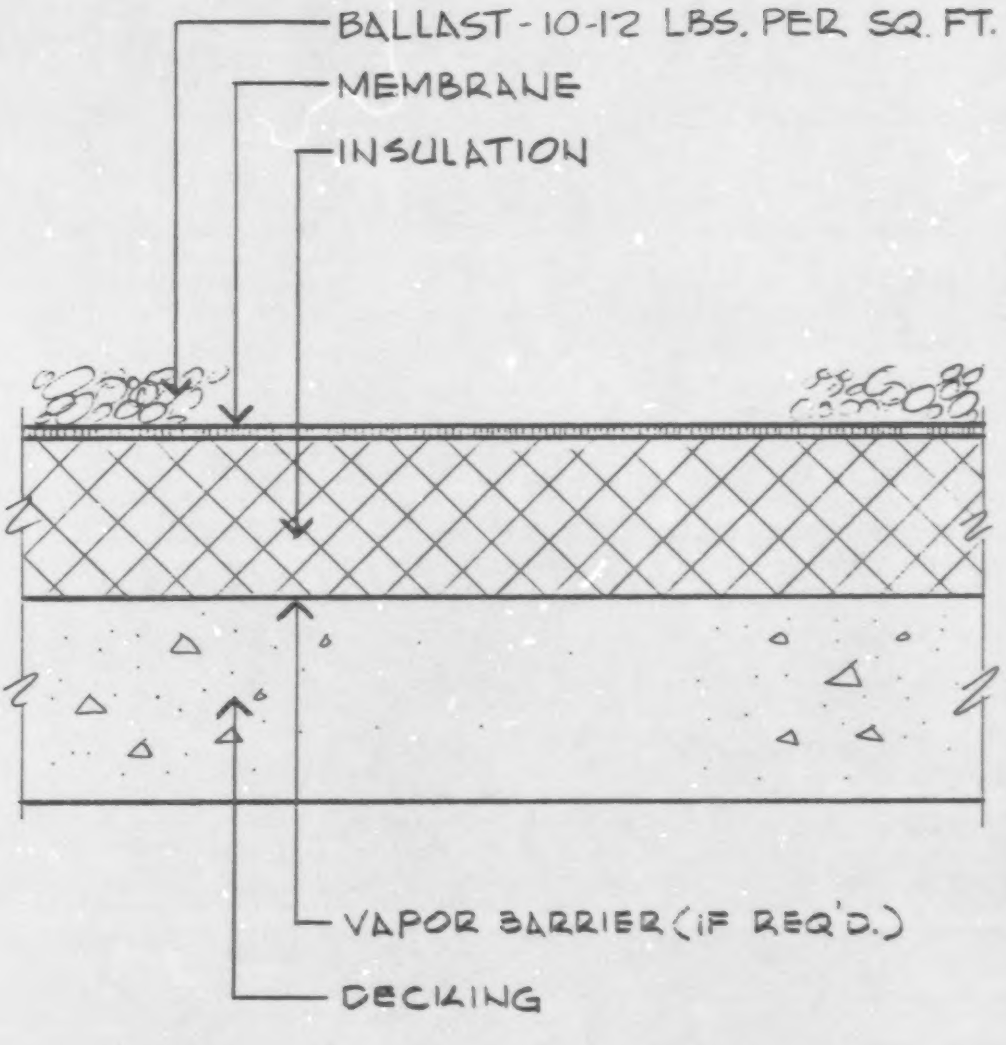
1. Elongation (at 0 degrees F) - 1% per foot of maximum distance between expansion joints or roof perimater.

2. Insulation compressive strength - Insulation (if required) to have compressive strength 10% greater than that necessary to resist ballast load plus required live/snow loading (as established by applicable building code).

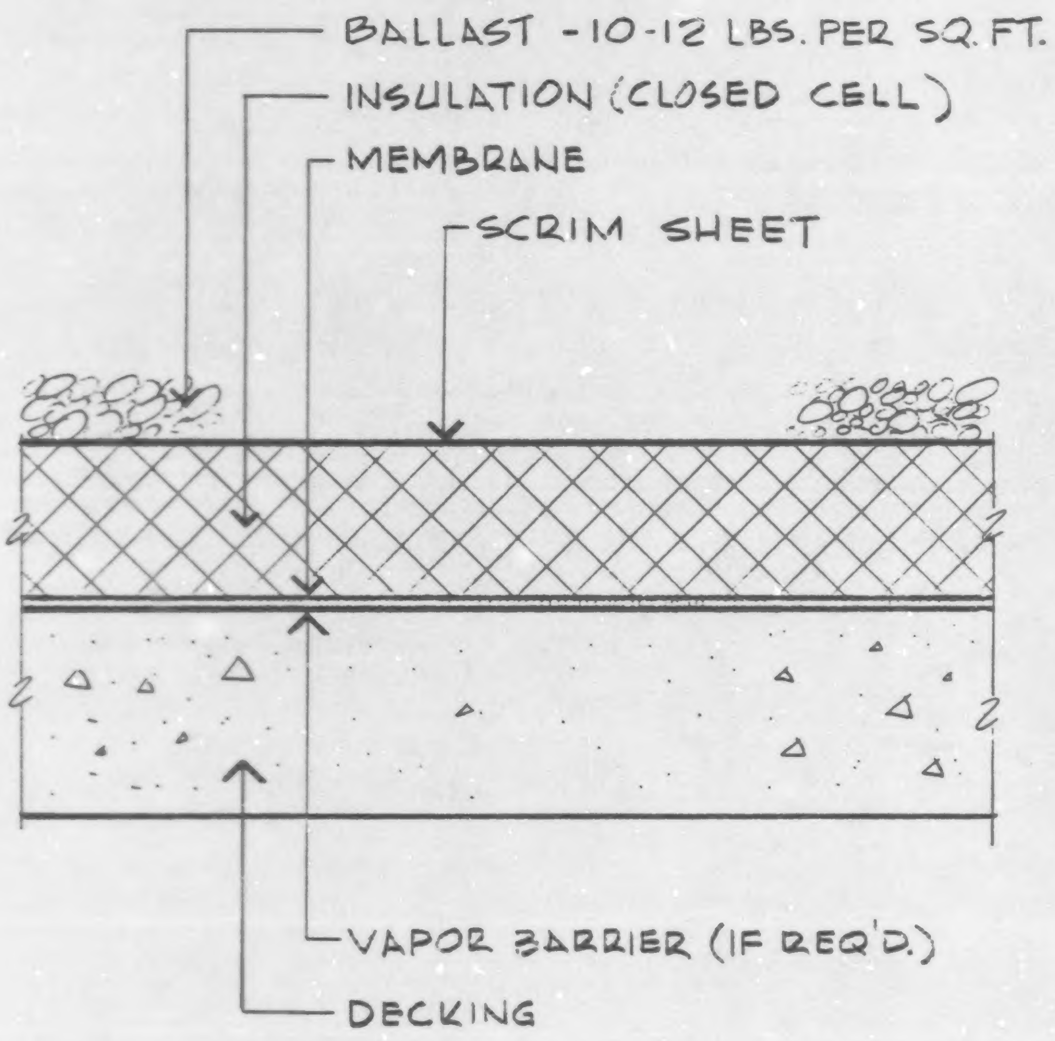
3. Dimensional stability - material change of less than 2%

ADD FOR PROTECTED MEMBRANE SYSTEM

4. Insulation must be closed cell and able to retain 95% of insulative capacity after insulation has been tested by water submersion test (modified ASTM D2842-69) and freeze-thaw cycling test (ASTM C666-73 Procedure B) 400 cycles minimum.


BALLAST - 10-12 LBS. PER SQ. FT.
MEMBRANE
INSULATION
VAPOR BARRIER (IF REQ'D.)
DECKING

BALLASTED SYSTEM


BALLAST - 10-12 LBS. PER SQ. FT.
INSULATION (CLOSED CELL)
MEMBRANE
SCRIM SHEET
VAPOR BARRIER (IF REQ'D.)
DECKING

PROTECTED MEMBRANE SYSTEM

MECHANICALLY FASTENED MEMBRANE SYSTEM

This type of attachment is preferred if ballasted assembly is not possible. This system depends upon mechanical fasteners to hold the system in place. Important design criteria for this type of system is the pullout strength of the fastener and roof deck and the tensile and tear strength of the material.

CHECKLIST FOR USE OF MECHANICALLY ATTACHED SYSTEMS

1. Is roof deck material suitable for mechanical attachment. (Screw-type fasteners - 22 gauge or heavier steel, or 3/4" plywood or equivalent; toggle-bolt fasteners - poured gypsum, tectum, or lightweight concrete.)

2. Is the underside of the deck exposed where the fasteners might show (typical of tectum and precast concrete).

3. Any other material(s) on bottom side of deck that should not be disturbed (such as asbestos fireproofing, electrical conduits, etc.).

MATERIAL SELECTION FOR MECHANICALLY ATTACHED SYSTEMS

1. Elongation (at 0 degrees F) - 3% per foot of maximum distance between fasteners

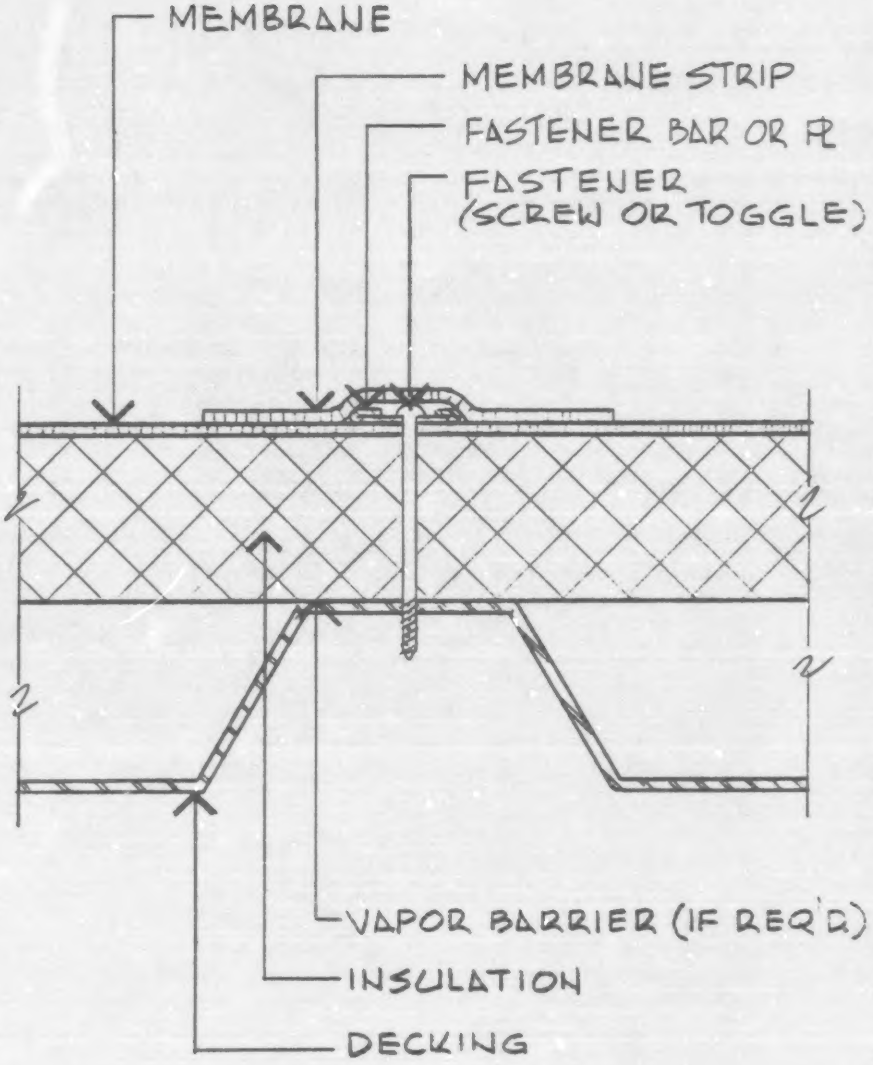
2. Tensile Strength - Minimum tensile strength of 2200 psi for materials with less than 100% elongation. Minimum tensile strength of 1400 psi for materials with more than 100% elongation.

3. Dimensional Stability - Change of less than 1% for materials with less than 100% elongation. Change of less than 2% for materials with more than 100% elongation.

4. Fire Resistance - Material shall be U.L. Class A (FM Class I can be substituted).

5. Wind Uplift - System under evaluation to have passed FM I-90 testing. In areas of extremely high wind conditions (excess of 70 m.p.h.), check with manufacturer for additional requirements.

6. Fasteners - Fasteners (either screw or toggle-bolt) to be acrylic or epoxy coated for maximum resistance to deterioration.


MEMBRANE
MEMBRANE STRIP
FASTENER BAR OR PL
FASTENER
(SCREW OR TOGGLE)
VAPOR BARRIER (IF REQ'D)
INSULATION
DECKING

MECHANICALLY FASTENED SYSTEM

FULLY ADHERED MEMBRANE SYSTEM

This attachment system is the least preferred method of installation. It is usually the most expensive and requires the highest standard of workmanship and materials.

CHECKLIST FOR ADHERED SYSTEM

1. Is building located in an area of extremely high winds where severe uplift forces are present (wind speeds in excess of 70 m.p.h.)?

2. Is either roof deck (new construction) or existing roof surface (reroofing) suitable for the attachment of manufacturer-approved insulation board?

MATERIAL SELECTION FOR FULLY ADHERED ROOF SYSTEM

1. Elongation (at 0 degrees F) - .5% per foot of maximum distance between expansion joints (300%+ is preferred).

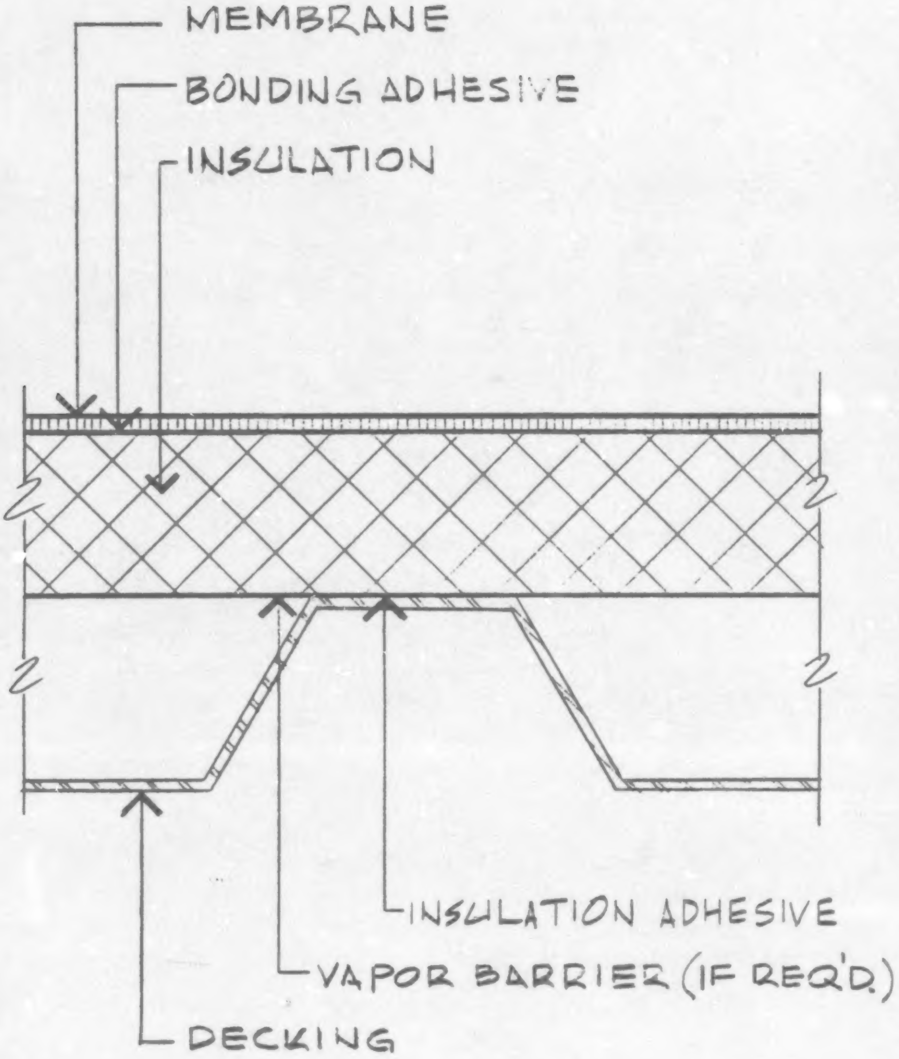
2. Dimensional Stability - Material change of less than .01%

3. Thermal Expansion - Coefficient of thermal expansion shall be less than .000030 in/in per 0 degrees F.

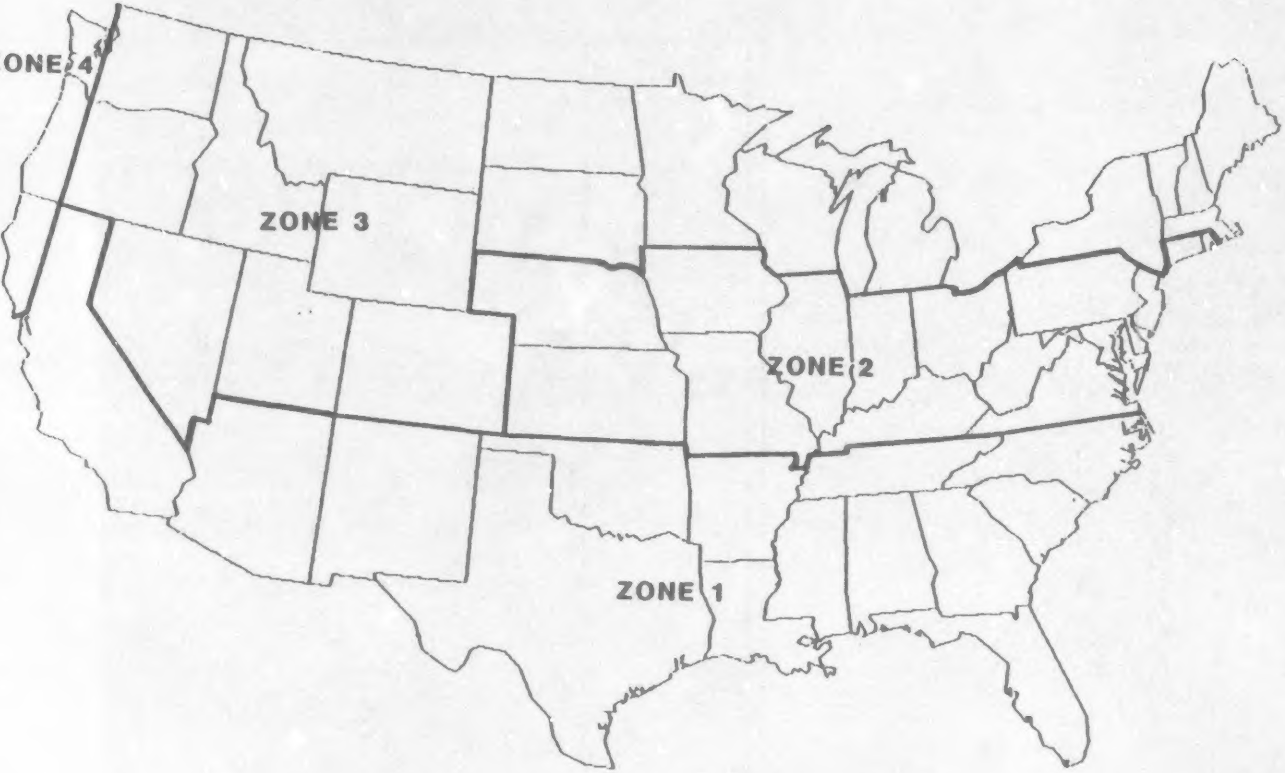
4. Wind Uplift - System shall pass Dade County wind uplift testing (200' minimum).

5. Insulation - Insulation to be of type used in Dade County wind uplift test.

6. Fire Resistance - Material shall pass test for U.L. Class A (FM Class I can be substituted).


MEMBRANE
BONDING ADHESIVE
INSULATION
INSULATION ADHESIVE
VAPOR BARRIER (IF REQ'D)
DECKING

FULLY ADHERED SYSTEM



Legend

Zone 1	Normal Low Temperature Above 32°F Normal High Temperature Above 100°F
Zone 2	Normal Low Temperature Above -25°F Normal High Temperature Above 100°F
Zone 3	Normal Low Temperature Below -25°F Normal High Temperature Below 90°F
Zone 4	Normal Low Temperature Above 32°F Normal High Temperature Below 90°F

GENERALIZED TEMPERATURE ZONES

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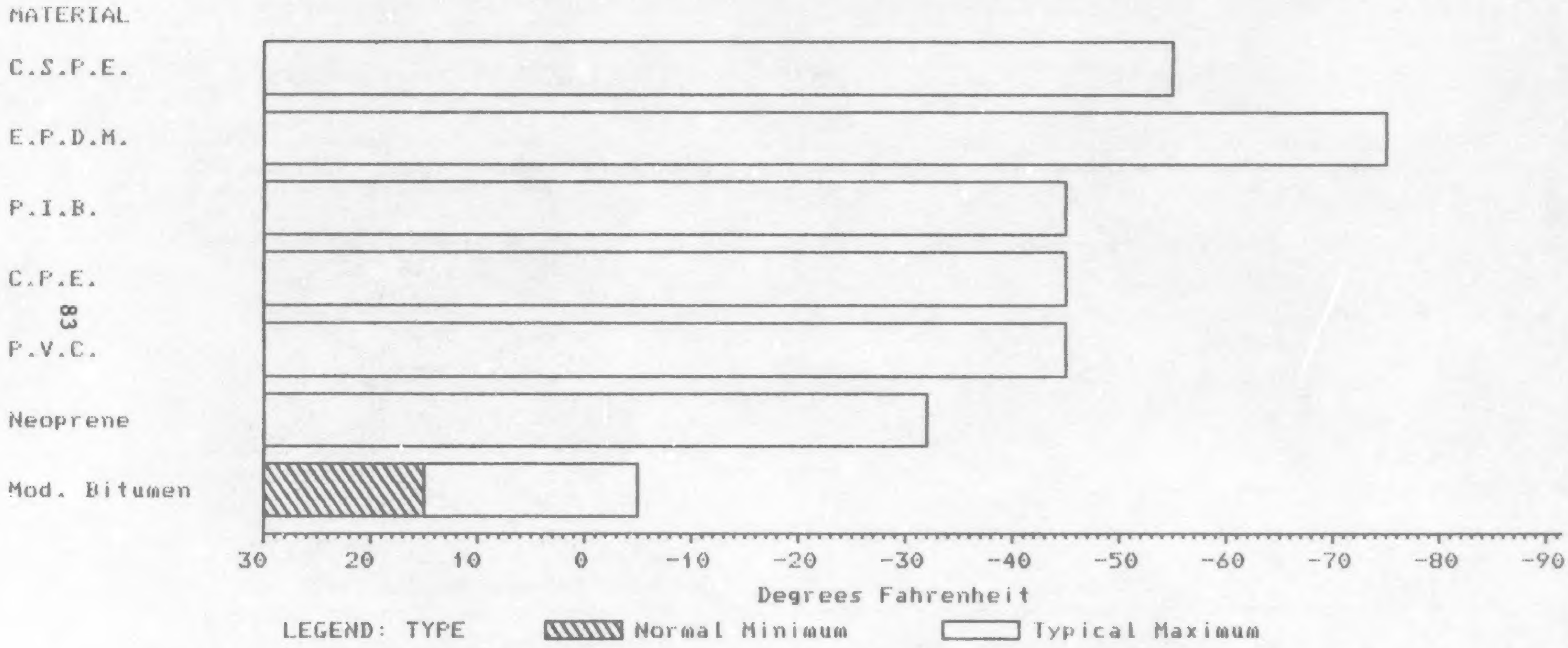
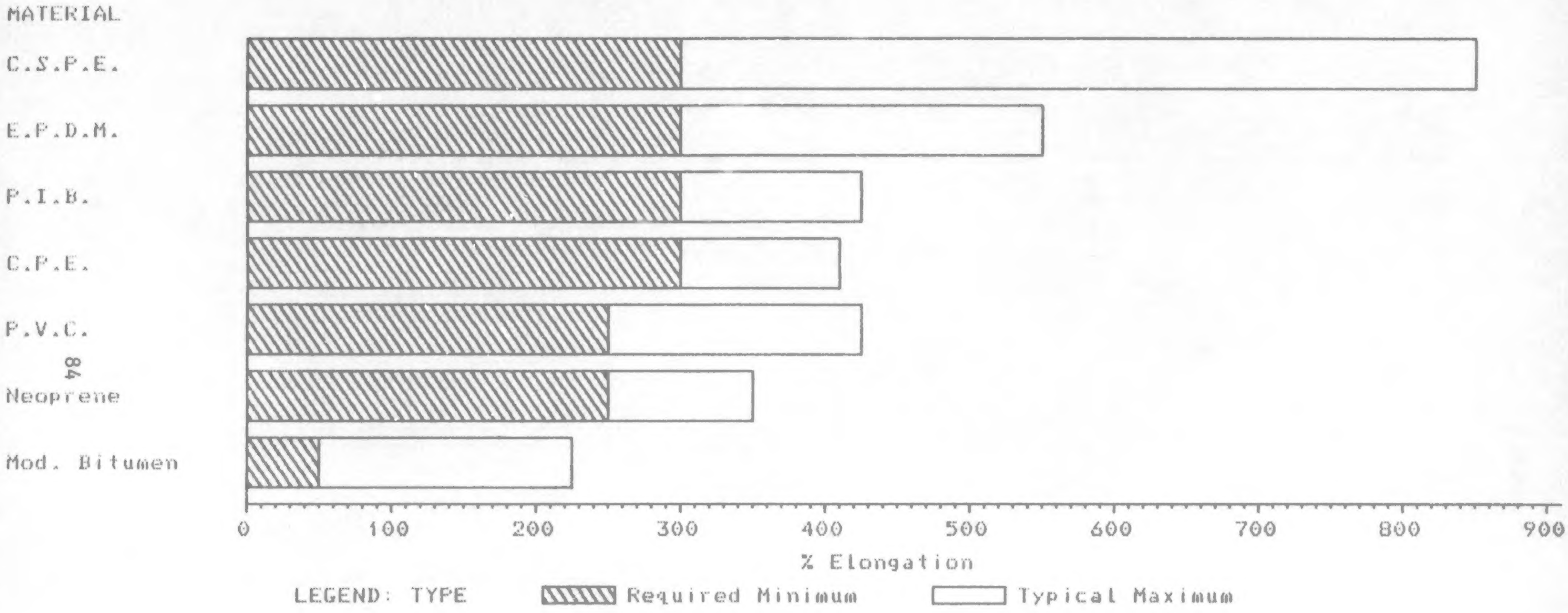
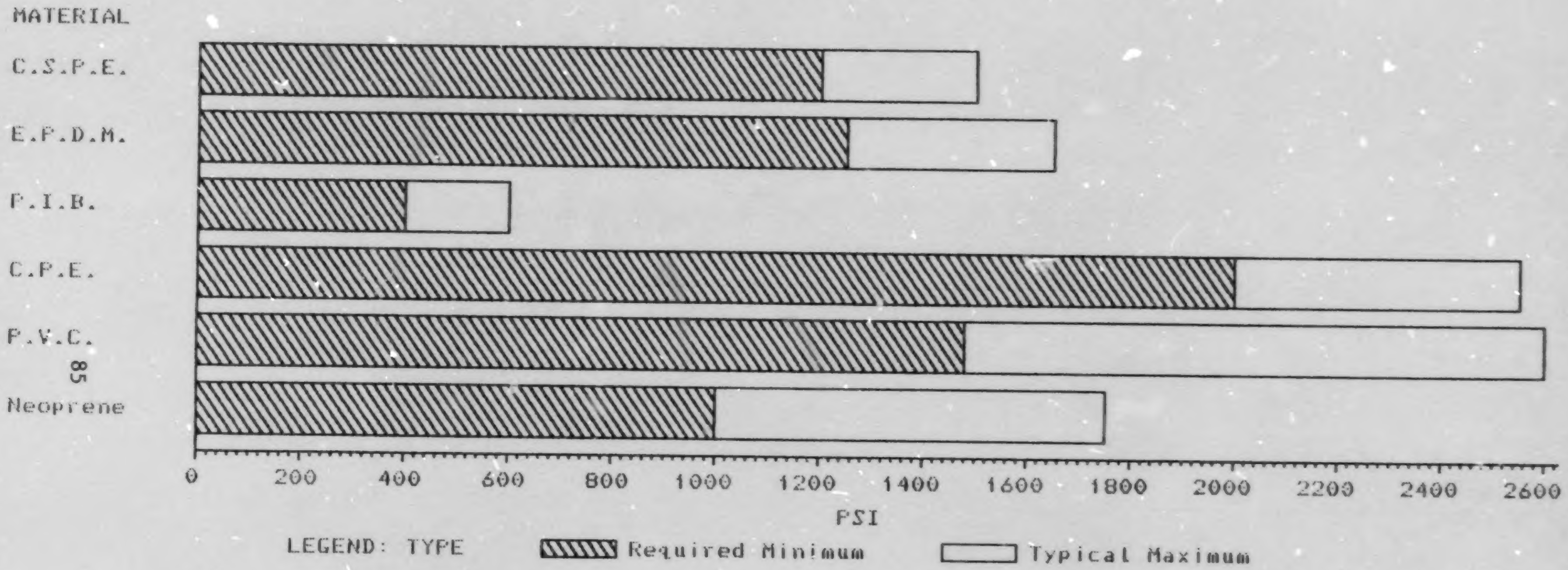
Low Temperature Flexibility



Elongation–unreinforced materials



Tensile Strength



C.P.E. (UNREINFORCED)

MANUFACTURER. ____________________

	TEST		TEST NO. ASTM	WEIGHTED FACTOR	MINIMUM	% OF MINIMUM
1.	Thickness			6	40 Mils.	
2.	Tensile Strength		D412	5	1800 psi	
3.	Elongation at Break		D412	8	300%	
4.	Lap Joint Strength		D412	8	90% of Mat	
5.	Low Temp. Flex.		D2136	10	-40 degrees F.	
6.	Heat Aging % Strength Retainage	6 Hrs. @ 176° C.	D1204/ D882 - D638			
		6A Tensile Strength or Breaking Strength		5	90% of original	
		6B Low Temp. Flex		8	80% of original	
		6C Elongation		9	90% of original	
7.	Dimensional Stability		D1204 6 Hrs @ 176° C.	4	2%	
8.	Water Absorb.		E96	5	2%	
9.	Dynamic Impact		FED. TEST METHOD 2031	7	9 psi	
10.	Accelerated Weathering		D750			
		% Retain Tensile Strength or % Retain Breaking Strength		5	90% of original	
11.	Class A		U.L.	10	Pass	
	TOTAL			90		

E.P.D.M. (NONREINFORCED)

MANUFACTURER. ____________________

	TEST	TEST NO. ASTM	WEIGHTED FACTOR	MINIMUM	% OF MINIMUM
1.	Thickness		6	45 Mils.	
2.	Tensile Strength	D412	5	1200 psi	
3.	Elongation at Break	D412	8	300%	
4.	Lap Joint Strength		6	75 lb/F.	
5.	Low Temp. Flex.	D746	8	-40 degrees F.	
6.	Tensile Set	D412	2	3% max.	
7.	Tear Resistance	D624	5	120 lb/in	
8.	Heat Aging % Strength Retain	D573			
8A	Tensile Strength Breaking Strength		5	90% original 90% original	
8B	Low Temp. Flex		10	90% original	
8C	Elongation		8	90% original	
8D	Dimensional Change		4	± 2%	
9.	Water Absorption	E96	4	3% maximum	
10.	Dynamic Puncturing	FED. TEST METHOD 2031	6	Pass @ 2 Ft. Lbs.	
11.	Accelerated Weathering % Retain Tensile Strength or % Retain Breaking Strength	D750	5	90%	
12.	Ozone Resistance	D1149	8	Pass	
	TOTAL		90		

NEOPRENE (NONREINFORCED) MANUFACTURER. ____________________

	TEST	TEST NO. ASTM	WEIGHTED FACTOR	MINIMUM	% OF MINIMUM
1.	Thickness		6	45 Mils.	
2.	Tensile Strength	D412	5	1200 psi	
3.	Elongation at Break	D412	8	250%	
4.	Lap Joint Strength		6	75 lb/F.	
5.	Low Temp. Flex.	D746	8	30 degrees F.	
6.	Tensile Set	D412	2	3% max.	
7.	Tear Resistance	D624	5	120 lb/in	
8.	Heat Aging % Strength Retain	D573			
8A	Tensile Strength Breaking Strength		5	90% original 90% original	
8B	Low Temp. Flex		10	90% original	
8C	Elongation		8	50% original	
9.	Water Absorption	E96	4	3% maximum	
10.	Dynamic Puncturing	FED. TEST METHOD 2031	6	Pass @ 2 Ft. Lbs.	
11.	Accelerated Weathering % Retain Tensile Strength or % Retain Breaking Strength	D750	5	90%	
12.	Ozone Resistance (20% strain)	D1149 - 100 PPHM ozone 100 Hrs. at 104 F.	8	Pass	
13.	Class A	U.L.	4	Pass	
	TOTAL		90		

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C.S.P.E. MANUFACTURER. ____________________

	TEST	TEST NO. ASTM	WEIGHTED FACTOR	MINIMUM	% OF MINIMUM
1.	Thickness		6	40 Mils.	
2.	Tensile Strength	D412	5	1400 psi	
3.	Elongation at Break	D412	8	350%	
4.	Lap Joint Strength	D412	8	90% of Mat	
5.	Low Temp. Flex.	D2136	10	-40 degrees F.	
6.	Heat Aging % Strength Retainage 6 Hrs. @ 176° C	D1204/ D882 - D638			
6A	Tensile Strength or Breaking Strength		5	90% of original	
6B	Low Temp. Flex		8	80% of original	
6C	Elongation		9	90% of original	
7.	Dimensional Stability	D1204 6 Hrs. @ 176° C	4	2% unreinforced .5% reinforced	
8.	Water Absorb.	E96	5	2%	
9.	Dynamic Impact	FED. TEST 101B METHOD 2031	7	9 psi	
10.	Accelerated Weathering	D750			
	% Retain Tensile Strength or % Retain Breaking Strength		5	90% of original	
11.	Class A	U.L.	10	Pass	
	TOTAL		90		

P.V.C. MANUFACTURER. ____________________

	TEST	TEST NO. ASTM	WEIGHTED FACTOR	MINIMUM	% OF MINIMUM
1.	Thickness		6	40 Mils.	
2.	Tensile Strength	D638/D882	5	1400 psi	
3.	Elongation at Break	D638/D882	8	250%	
4.	Lap Joint Strength	D638/D882	8	90% of Mat	
5.	Low Temp. Flex.	D2136	10	-40 degreesF.	
6.	Heat Aging % Strength Retainage	D1204/ D882 - D638			
6A	Tensile Strength or Breaking Strength		5	90% of original	
6B	Low Temp. Flex		8	80% of original	
6C	Elongation		5	90% of original	
7.	Dimensional Stability	D1204 6 Hrs. @ 100° C	4	2% unreinforced .5% reinforced	
8.	Water Absorb.	E96	5	2%	
9.	Dynamic Impact	FED. TEST 101B METHOD 2031	7	Pass @ 2 FT. LBS.	
10.	Accelerated Weathering	D750			
	% Retain Tensile Strength or % Retain Breaking Strength		5	90% of original	
1.	Class A	U.L.	10	Pass	
	TOTAL		90		

90

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NEOPRENE (REINFORCED)

MANUFACTURER. ____________________

	TEST	TEST NO. ASTM	WEIGHTED FACTOR	MINIMUM	% OF MINIMUM
1.	Thickness		6	40 Mils.	
2.	Tensile Strength	D751	7	2000 psi	
3.	Elongation at Break	D751	8	250%	
4.	Lap Joint Strength	D751	6	75 lb/F.	
5.	Low Temp. Flex.	D2137	8	-30 degrees F.	
6.	Tear Resistance	D624	5	120 lb/in	
7.	Heat Aging % Strength Retainage	D573			
7A	Tensile Strength Breaking Strength		5	90% original 90% original	
7B	Low Temp. Flex		10	90% original	
7C	Elongation		8	90% original	
8.	Water Absorption	E96	4	3% maximum	
9.	Dynamic Puncturing	FED. TEST 101B METHOD 2031	6	Pass @ 2 Ft. Lbs.	
10.	Accelerated Weathering % Retain Tensile Strength or % Retain Breaking Strength	D750	5	90%	
11.	Ozone Resistance (20% strain)	D1149 - 100 PPHM ozone 100 Hrs. at 104° F.	8	Pass	
12.	Class A	U.L.	4	Pass	
	TOTAL		90		

MODIFIED BITUMEN

MANUFACTURER. ____________________

	TEST	TEST NO. ASTM	WEIGHTED FACTOR	MINIMUM	% OF MINIMUM
1.	Coefficient of Expansion	NBS-55	6	.0003 in./in. Mils. per 0 F.	
2.	Tensile Strength	D2523	5	130 in./lb.	
3.	Elongation at Break (0° F.)	D412	9	10%	
4.	Lap Joint Strength 3" Lap	D2523	6	100% of material strength	
5.	Low Temp. Flex.	90 Bend Radius	8	-10 degrees F.	
6.	Thermal Shock	D412	7	300 degrees F. min.	
7.	Tear Resistance	D751	5	120 lb./in.	
8.	Heat Aging % Strength Retain	D2523 24 hrs. @ 176° F.			
8A	Tensile Strength Breaking Strength		5	90% original 90% original	
8B	Low Temp. Flex		8	90% original	
8C	Elongation		8	90% original	
9.	Water Absorption	E96	4	less than 1.0% dimensional change	
10.	Dynamic Puncturing	FED. TEST METHOD 2031	6	Pass @ 2 ft. lbs.	
11.	Accelerated Weathering % Retain Tensile Strength or % Retain Breaking Strength	D2665 G-23 & G-25 10,000 hrs.	5	90%	
12.	Hail Damage	F.M.	8	Pass	
	TOTAL		90		

C.P.E. (REINFORCED)

MANUFACTURER. ____________________

TEST	TEST NO. ASTM	WEIGHTED FACTOR	MINIMUM	% OF MINIMUM
1. Thickness		6	40 Mils.	
2. Tensile Strength	D751	5	2000 psi	
3. Elongation at Break	D751	8	25%	
4. Lap Joint Strength	D751	8	90% of Mat	
5. Low Temp. Flex.	D2137	10	-40 degrees F.	
6. Heat Aging % Strength Retainage 6 Hrs. @ 176 C.	D1204/ D882 - D638			
6A Tensile Strength or Breaking Strength		5	90% of original	
6B Low Temp. Flex		8	80% of original	
6C Elongation		9	90% of original	
7. Dimensional Stability	D1204 6 Hrs. @ 176 C.	4	2%	
8. Water Absorb.	E96	5	2%	
9. Dynamic Impact	RED. TEST METHOD 2031	7	9 psi	
10. Accelerated Weathering	D750			
% Retain Tensile Strength or % Retain Breaking Strength		5	90% of original	
11. Class A	U.L.	10	Pass	
TOTAL		90		

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POLYVINYLCHLORIDE

Product name	Nervaply JB	Sarnafil G21-410	Sarnafil G21-442	Sarnafil B21-327	Flexhide 34	Flexhide 45	Flexhide LR-50	Flagon SF	Flagon C	Trocal Roofing	GenSeal ACR
Supplier	Rubber Plastic Compound Co.	Sunafil (US) Inc.			U.S. Mineral Products Co.			Wat Pro, Inc.		Membrane Dynamit Nobel of America	GTR Building Products
1. Thickness (mm)	1.2	1.2						1.2	1.2	-	-
ASTM D374 (mils)	-	-						-	-	48	45
2. Tensile Strength (PSI)	2,610	1,566						1,250	2,600	> 2,400	2,100
ASTM D412 (PSI)											
ASTM D751 (lbs)											
Breaking Strength (Lbf)											
3. Lab Joint Strength	NA	103						95	80	NA	NA
ASTM D412 (%)											
ASTM D751 (%)											
Before exposure (Lbf)											
After exposure (Lbf)											
After immersion (%)		105						-	-	-	-
4. Elongation at Break (%)	275	425						240	350	> 250	300
ASTM D412											
ASTM D1682								-	-	-	-
5. Tensile Set %	NA	NA									
ASTM D412											
6. Low Temperature Flexibility	Pass	Pass						Pass	Pass	-58°F	-60°F
ASTM D746											
ASTM D2138 1/8" Mandrel											
7. Water Absorption	NA		NOT AVAILABLE	NOT AVAILABLE	NOT AVAILABLE	NOT AVAILABLE		-	-	NA	NA
Change in mass											
ASTM E96 (%)	-	1.29						2.6	1.8	-	-
Tensile Strength PSI	-	1,610						-	-	-	-
Breaking Strength Lbf											
8. Dynamic Impact (Puncturing)	NA	NA						NA	NA	NA	NA
Fed. Test 101B Method 2031											
9. Tear Resistance (Lbf)	NA	NA						NA	NA	NA	NA
ASTM D624											
10. Tearing Strength Lbf	NA	NA						NA	NA	NA	NA
ASTM D751											
11. Low Temperature Impact	Pass	Pass						Pass	Pass	NA	NA
ASTM D746											
12. Permeability	0.4	1.21						2.8	2.8	NA	NA
ASTM E96 g/m^2d											
13. Cone Penetration	NA	10.6						NA	NA	NA	NA
DIN 53443											
14. Heat Aging & Strength Retain	100	-						-	97	100	99
Tensile Strength PSI	-	103						-	-	-	-
Breaking Strength Lbf	-	-						-	-	-	-
Low Temperature Flexibility	-	-						-	-	-	-
Elongation at Break (%)	7	1						-	-	-	-
Dimensional Change (%)								-	-	-	-
15. Accelerated Weathering Resistance	Pass	Pass						Pass	Pass	Pass	Pass
								-	-	-	-
% Retain Tensile Strength	-	-						-	-	-	-
% Retain Breaking System	-	-						-	-	-	-
minimum Tensile PSI	-	-						-	-	-	-
minimum Breaking Lbf	-	-						-	-	-	-
16. Ozone Resistance	-	-						-	-	-	-
no cracks under 7X											
ASTM D3041 100 h											
17. Installed Weight	0.49	0.33	0.33	0.37	0.23	0.30	0.32	0.35	NA	0.35	0.30
PSF w/o Ballast											
18. Warranty Years	10	10	10	10	5 or 10	5 or 10	5 or 10	10	10	10	10
19. First Year of Servie	1981	1964	1964	1964	1978	1980	1978	1963	1963	1973	1980
20. Factory Mutual (FM) Class 1	NA	Pass	NA	Pass	NA	NA	Pass	Pass	NA	Pass	Pass
Underwriters Laboratory (UL) Class A	Pass	Pass	Pass	Pass	Pass	Pass	Pass	NA	Pass	Pass	Pass

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NEOPRENE, CHLORINATED POLYETHYLENE, HYPALON

	Neoprene				Chlorinated Polyethylene (CPE)					HYPALON CSPE (Chlorosulfonated Polyethylene)				
Product Name	Sure-Seal Neoprene	Sure-Seal Neoprene	Plyshield Neoprene	Gaco System II/N-15	Alkorflex 35091	Alkorflex 35096	Alkorflex 35096	Flexhide CPE	Cool Top 40	ERD/Burke M&B	Hi-Tuff Roofing	Tremply Ballasted	Temply 120	Unìroof
Supplier	Type 1 Carlisle Syntec	Type 2 Carlisle Syn Tec	Type 2 Plymouth Rubber Co.	Gates Engineering Co	Alkor Division of the Solving American Corporation			U.S. Min Prod. Co.	Cooley Roofing System	ERD System Burke Rubber	J. P. Stevens & Co.	Tremco Inc.	Tremco Inc.	Uniroof/ Central Associates
1. Thickness (mm)	1.143	1.524	0.8	-	-	-	-	-	-	-	-	-	-	-
ASTM D374 (mils)	-	-	-	60	48	40	44	45	40	36	45	37	40	35
2. Tensile Strength (PSI)	1,750	1,750	-	-	-	-	-	-	-	-	-	-	-	-
ASTM D412 (PSI)	-	-	-	1,800	< 2,000	< 2,000	< 2,206	-	2,500	1,200	1,400		1,458	1,200
ASTM D751 (lbs)	-	-	80	-	-	-	-	224	-	-	-	400	-	-
Breaking Strength (Lbf)	-	-	90	-	-	-	-	-	-	-	-	-	-	-
3. Lab Joint Strength	TBD	TBD		NA	-	-	-	-	-	-	-	-	-	-
ASTM D412 (%)	-	-	-	-	< 75	< 75	< 75	-	NA	NA	NA	NA	NA	NA
ASTM D751 (%)	-	-	-	-	-	-	-	92	-	-	-	-	-	-
Before exposure (Lbf)	-	-	76	-	-	-	-	-	-	-	-	-	-	-
After exposure (Lbf)	-	-	69	-	-	-	-	-	-	-	-	-	-	-
After immersion (%)	-	-	90	-	-	-	-	-	-	-	-	-	-	-
4. Elongation at Break (%)	360	NA	250	-	-	-	-	-	27	-	-	-	-	-
ASTM D412	-	-	-	350	< 400	< 400	-	NL	-	250	400	250	748	600
ASTM D1682	-	-	-	-	-	-	> 15	-	-	-	-	-	-	-
5. Tensile Set %	1	NA	NA	-	-	-	NA	NA	NA	NA	NA	NA	NA	NA
ASTM D412	-	-	-	-	< 5	< 5	-	-	-	-	-	-	-	-
6. Low Temperature Flexibility	Pass	Pass	Pass	-	-50°F	-40°F	-40°F	-	-40°F	-	-	-	-	-
ASTM D746	-	-	-	-42°F	-	-	-	Pass	-	-	-	-60°F	-60°F	-40°F
ASTM D2138 1/8" Mandrel	-	-	-35°F	-	-	-	-	-40°F	-	-45°F	-45°F	-	-	-
7. Water Absorption	± 10	± 10	3.4	NA	-	-	-	NA	NA	NA	NA	NA	NA	NA
Change in mass														
ASTM E96 (%)	-	-	-	-	< 1	< 1	< 1	-	-	-	-	-	-	-
Tensile Strength PSI	TBD	TBD	-	-	-	-	-	-	-	-	-	-	-	-
Breaking Strength Lbf	-	-	88	-	-	-	-	-	-	-	-	-	-	-
8. Dynamic Impact (Puncturing)	Pass	Pass	-	-	NT	NT	NT	NA	NA	NA	NA	NA	NA	NA
Fed. Test 101B Method 2031	-	-	80 lb	-	-	-	-	-	-	-	-	-	-	-
9. Tear Resistance (Lbf)	MD6.6;	NA	NA	NA	> 27.9	> 27.9	> 84.2	NA	NA	NA	NA	NA	NA	NA
ASTM D624	D26.6	-	-	-	-	-	-	-	-	-	-	-	-	-
10. Tearing Strength Lbf	NA	NA	10	NA	NA	NA	NA	-	NA	NA	NA	NA	NA	NA
ASTM D751								81						
11. Low Temperature Impact	NA	NA	NA	NA	-	-	-	Pass	NA	NA	NA	NA	NA	NA
ASTM D746	-	-	-	-	-50°F	-50°F	-60°F	-50°F	-	-	-	-	-	-
12. Permeability	NA	NA	NA	NA	0.5	0.6	0.6	0.4 Perm	-	-	-	-	-	-
ASTM E96 g/m²d							(d=1.2mm)							
13. Cone Penetration	NA	NA	NA	NA	-	-	-	NA	NA	NA	NA	NA	NA	NA
DIN 53463					1600 N @ 23°C	1600 N @ 23°C	1500 N @ 21°C							
14. Heat Aging % Strength Retain	TBD	-	85	100	Pass	Pass	Pass	100	NA	100	100	100	100	100
Tensile Strength (PSI	TBD	-	-	-	-	-	-	-	-	-	-	-	-	-
Breaking Strength (Lbf)	-	-	98	-	-	-	-	-	-	-	-	-	-	-
Low Temperature Flexibility	Pass	Pass	Pass	-	-	-	-	-	-	-	-	-	-	-
Elongation at Break (%)	TBD	-	205	-	-	-	-	-	-	-	-	-	-	-
Dimensional Change (%)	0.5	-	1.0	± 2	-	-	-	-	-	-	-	-	-	-
15. Accelerated Weather Resistance	Pass	Pass	Pass	-	20,000	20,000	20,000	NA	NA	NA	NA	NA	NA	NA
% Retain Tensile Strength	TBD	-	-	-	-	-	-	-	-	-	-	-	-	-
% Retain Breaking Strength	-	-	95	-	-	-	-	-	-	-	-	-	-	-
minimum tensile (PSI)	TBD	-	-	-	-	-	-	-	-	-	-	-	-	-
minimum breaking Lbf	-	-	95	-	-	-	-	-	-	-	-	-	-	-
16. Ozone Resistance														
no cracks under 7X	Pass	Pass	Pass	Pass	Pass	Pass	Pass	NA	NA	NA	NA	NA	NA	NA
ASTM D1041 100h														
17. Installed Weight														
PSF w/o Ballast	NA	0.46	0.28 (0.23)	0.452	0.33	0.30	0.30	0.30	0.31	0.25	0.29	0.25	0.13	0.25
18. Warranty Years	NA	10	10	10	10	10	10	5 or 10	10	10 to 15	5+5	5+5	5+5	10
19. First Year of Service	NA	1960	1963	1963	1973	1976	1974	1982	1977	1970	1977	1980	1964	1979
20. Factory Mutual (FM) Class 1	NA	NA	NA	Class 1	NA	NA	1-90	NA	1-90	1-90	1-90	NA	160-90	NA
Underwriters Laboratory (UL) Class A	NA	NA	Pass	NA	Pass	IT	Class A	NA	Class A	IT	Class A Pending	Class A	Class A	1-90 to Class B&C

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Product Name	Alkorplan	Rhenofol C 34	Rhenofol C 45	Rhenofol C 52	Rhenofol CV 40	Rhenofol CV 48	Interroof 'A' Unballasted	Interroof "B" Ballast	Plyroof PVC Grey	Plyroof PVC White	Sucoflex F132	Sucoflex F127	Nervaply
Supplier	Alkor Division Solvay American Corp.	------------Barra Corporation of America------------					I PW Interplastic		Plymouth Rubber Co.		PMS/Sucoflex		Rubber & Plastics Compound Co.
1. Thickness (mm)	1.2					-	-	-	1.14	1.14	-		1.2
ASTM D374 (mils)	-					48	60	40	-	-	48		-
2. Tensile Strength (PSI)	2,800					2,800	2,870	2,870	2,147	2,147	1,420		2,610
ASTM D412 (PSI)													
ASTM D751 (lbs)													
Breaking Strength (Lbf)													
3. Lab Joint Strength (not less 75%)	Pass					NA	NA	NA	76%	76%	NA		NA
ASTM D412 (%)													
ASTM D751 (%)													
Before exposure (Lbf)													
After exposure (Lbf)													
After immersion (%)	-					-	-	-	74	74	-		-
4. Elongation of Break (%)	> 350					220	360	360	260	260	270		275
ASTM D412													
ASTM D1682													
5. Tensile Set %	NA					NA	NA	NA	NA	NA	NA		
ASTM D412													
6. Low Temperature Flexibility	Pass					-40°F	-40°C	-40°C	Pass	Pass	-40°F		Pass
ASTM D745							Pass	Pass					
ASTM D2136 1/8" Mandrel		NOT AVAILABLE	NOT AVAILABLE	NOT AVAILABLE	NOT AVAILABLE								
7. Water Absorption	-					NA	NA	NA	-	-	NA		NA
Change in mass %	1					-	-	-	0.93	0.93	-		-
ASTM E96 (%)													
Tensil Strength PSI	NT					-	-	-	1,867	1,867	-		-
Breaking Strength Lbf	NT												
8. Dynamic Impact (Puncturing)	NA					NA	NA	NA	NA	NA	NA		NA
Fed. Test 101B method 2031													
9. Tear Resistance (Lbf)	NA					NA	-	-	NA	NA	NA		NA
ASTM D624													
ASTM D1004	-					-	17.0	17.0	-	-	-		-
10. Tearing Strength Lbf	NA					-	NA	NA	NA	NA	NA		NA
ASTM D751													
11. Low Temperature Impact	NA					-	-38.8°C	-38.8°C	Pass	Pass	Pass		NA
ASTM D746													
12. Permeability													
ASTM E96 g/m²d	2.35					-	0.141 Perm	0.141 Perm	2.24	2.24	3.0		0.4
13. Cone Penetration	NT					-	-	-	-	-	-		-
DIN 53443							NA	NA	9	9	NA		NA
14. Heat Aging & Strength Retain	-					-	-	-	Pass	Pass	Pass		100
Tensile Strength (PSI)	-					-	-	-	8	8	-		-
Breaking Strength (Lbf)	-					-	-	-	-	-	-		-
Low Temperature Flexibility	-					-	-	-	Pass	-	-		-
Elongation at Break (%)	< 30					-	-	-	9	9	-		-
Dimension Change (%)	< 1.5					0.5	-	-	-	-	-		-
15. Accelerated Weather Resistance	Pass					Pass	Pass	Pass	Pass	Pass	Pass		Pass
% Retain Tensile Strength	-					-	-	-	-	-	-		-
% Retain Breaking Strength	-					-	-	-	-	-	-		-
minimum Tensile (PSI)	-					-	-	-	-	-	-		-
minimum Breaking (Lbf)	-					-	-	-	-	-	-		-
16. Ozone Resistance													
no cracks under 7X	-					-	-	-	-	-	-		-
ASTM D3041 100h													
17. Installed Weight	0.33	0.23	0.30	0.336	0.266	0.327	0.40	0.30	0.32	0.32	0.33	0.33	0.36
PSF w/o Ballast													
18. Warranty Years	10	5/10	5/10	5/10	5/10	5/10	10	10	10	10	10	10	10
19. First Year of Service	1970	1966	1966	-	1966	1976	1970	1968	1975	1981	1969	1969	1980
20. Factory Mutual (FM) Class 1	NA	Pass	Pass	NA	Pass	Pass	Pass	NA	Pass	Pass	Pass	Pass	NA
Underwriters Laboratory (UL)	Pass	Pass	Pass	NA	Pass	Pass	NA	NA	Pass	Pass	Pass	Pass	Pass
Class A													

ETHYLENE PROPYLENE DIENE MONOMER

Product Name	SMI Rubber Roof Black	SMI Rubber Roof White	Agaper E	0.045 Weather-gard	Benoit, EPDM	Celo-1	Garo System 1-B/E-2S	Gen Flex ACR Roofing System	Versigard Roofing System	Poly Ken Roofing System	SPM Roofing System	Superoof
Supplier	SYenergy Methods, Inc.		Wat Pro Inc	Weather-gard	Benoit Inc.	Celotex Corp.	Gates Engineering	General Tire Bldg.Products	Goodyear Tire & Rubber Co.	The Kendall Company	Manville Bld.Mat.	Protective Coatings
1. Thickness (mm)	1.397	1.397	1.1	1.042	-	-	-	-	-	-	-	-
ASTM D374 (mils)					45	45	45	60	45	45	45	45
2. Tensile Strength (PSI)	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,450	1,300	1,400	1,400	1,400
ASTM D412 (PSI)	-	-	-		-	-	-	-	-	-	-	-
ASTM D751 (lbs)	-	-	-	-	-	-	-	-	-	-	-	-
Breaking Strength (Lbf)	-	-	115	-	-	-	-	-	-	-	-	-
3. Lab Joint Strength	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ASTM D412 (%)												
ASTM D751 (%)												
Before exposure (Lbf)	-	-	-	82	-	-	-	-	-	-	-	-
After exposure (Lbf)	-	-	-	NT	-	-	-	-	-	-	-	-
After immersion (%)	-	-	-	NT	-	-	-	-	-	-	-	-
4. Elongation at Break (%)	300	300	350	300	300	300	300	255	300	300	350	300
ASTM D412												
ASTM D1682												
5. Tensile Set %	NA	NA	4.0	+4	NA	NA	NA	NA	NA	NA	NA	NA
ASTM D412												
6. Low Temperature Flexibility	Pass	Pass	Pass	Pass	-50°F	-62°F	-40°F	-67°F	-67°F	-75°F	-75°F	-62°F
ASTM D746												
ASTM D2138 1/8" Mandrel												
7. Water Absorption	NA	NA	-	-	NA	NA	NA	NA	NA	NA	NA	NA
Change in mass	-	-	3.5	3	-	-	-					
ASTM E96 (%)								-	-	-	-	-
Tensile Strength PSI	-	-	-	-	-	-	-	-	-	-	-	-
Breaking Strength Lbj	-	-	-	-	-	-	-	-	-	-	-	-
8. Dynamic Impact (Puncturing)	Pass	Pass	Pass	NT	NA	NA	NA	NA	NA	NA	NA	NA
Fed. Test 101B Method 2031												
9. Tear Resistance (Lbf)	125	NA	NA	11.11	NA	NA	NA	NA	NA	NA	NA	NA
ASTM D624												
10. Tearing Strength Lbf	NA	NA	NA	NT	NA	NA	NA	NA	NA	NA	NA	NA
ASTM D751												
11. Low Temperature Impact	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ASTM D746												
12. Permeability	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ASTM E96 g/m²d												
13. Cone Penetration	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
DIN 53443												
14. Heat Aging % Strength Retain	-	-	110	-	-	75	100	99	excellent	-	100	-
Tensile Strength PSI	1,225	1,225	-	1,200	1,400	-	-	-	-	1,200	1,400	-
Breaking Strength Lbf	-	-	-	-	-	-	-	-	-	-	-	-
Low Temp. Flexibility	Pass	Pass	Pass	-	-	-	-	-	-	-	-	-
Elongation at Break	225	225	300	210	250	-	-	-	-	225	250	-
Dimensional Change (%)	-	-	-	±2	±2	< 0.38	2	1	2	2	< 1	1
15. Accelerated Weathering Resistance	Pass	Pass	-	-	-	-	-	-	-	-	-	-
% Retain Tensile Strength	-	-	-	NT	-	-	-	-	-	-	-	-
% Retain Breaking Strength	-	-	-	NA	-	-	-	-	-	-	-	-
minimum tensile PSI	-	-	-	NT	-	-	-	-	-	-	-	-
minimum breaking Lbf	-	-	-	NA	-	-	-	-	-	-	-	-
16. Ozone Resistane												
no cracks under 7X	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
ASTM D3041 100h												
17. Installed Weight												
PSF w/o Bellast	0.35	0.35	0.31	0.28	0.3	0.28	0.26	0.35	0.28	0.28	0.245	0.28
18. Warranty Years	6 or 12	6 or 12	5/10	10	to 15	5/10	10	10	5,10,15	10	5,10,15	10
19. First Year of Service	1965	1965	1970	1981	1978	1967	1981	1981	1966	1982	1979	1967
20. Factory Mutual (FM) Class 1	Pass	Pass	NA	Pass	160+190	NA	NA	NA	1-90	IT	1-60,1-90	IT
Underwriters Laboratory (UL) Class A	Pass	Pass	NA	Pass	Pass	Pass	Pass	Pass	Pass	IT	Pass	IT

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Product Name	EPDM 450	EPDM 600	Sure-Seal EPDM	Rubber Gard 0.045"	Rubber Gard 0.060"	Galply EP Ballasted	Galply EP Fully Adhered	Whaleskin/81 C-EPDM	Whaleskin/81 White EPDM	Whaleskin/81 White C-EPDM	Whaleskin/81 EPDM	Plyscol EPDM	Reevetech
Supplier	Carboline Co.		Carlisle	Firestone Industrial Products		GAF Corporation		Kelly Energy				Plymouth Rubber	Reeves Bros.
1. Thickness (mm)	1.15	1.5	1.43, 1.524	1.14	1.52			-	-	-	-	1.02	1.15
ASTM D374 (mils)	-	-	-	-	-			45	45	45	45	-	-
2. Tensile Strength (PSI)	1,400	1,400	1,660	1,650	1,650			1,445	1,774	1,774	1,445	-	1,700
ASTM D412 (PSI)	-	-	-	-	-			-	-	-	-	-	-
ASTM D751 (lbs)	-	-	-	-	-			-	-	-	-	-	-
Breaking Strength (Lbf)								-	-	-	-	89	
3. Lab Joint Strength			TBD	IT	IT			NA	NA	NA	NA	-	-
ASTM D412 (%)													
ASTM D751 (%)													
Before exposure (Lbf)	90	90	-	-	-			-	-	-	-	72	240
After exposure (Lbf)	77	77	-	-	-			-	-	-	-	68	240
After immersion (%)	90	90	-	-	-			-	-	-	-	94	-
4. Elongation at Break (%)	300	300	500	450	450			320	390	390	390	300	350
ASTM D412													
ASTM D1682													
5. Tensile Set (%)	< 5	< 5	1	< 5	< 5			NA	NA	NA	NA	NA	0.5
ASTM D412													
6. Low Temperature Flexibility	Pass	Pass	Pass	Pass	Pass			Pass	Pass	Pass	Pass	Pass	Pass
ASTM D746													
ASTM D2138 1/8" Mandrel													
7. Water Absorption													
Change in mass	< 2	< 2	2	+ 2	+ 2	NOT AVAILABLE	NOT AVAILABLE	2.2	1.2	3.2	2.2	0.2	1.0
ASTM E96 (%)													
Tensile Strength PSI	1,260	1,260	TBD	-	-			-	-	-	-	-	-
Breaking Strength Lbf												90	-
8. Dynamic Impact (Puncturing)	Pass	Pass	Pass	Pass	Pass			NA	NA	NA	NA	NA	Pass
Fed. Test 101B Method 2031													
9. Tear Resistance (Lbf)	14	14	7.4	NA	NA			NA	NA	NA	NA	NA	7
ASTM D624													
10. Tearing Strength Lbf	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA	NA
ASTM D751													
11. Low Temperature Impact	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA	NA
ASTM D746													
12. Permeability													
ASTM E96 g/m^2d	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA	NA
13. Cone Penetration													
DIN 53463	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA	NA
14. Heat Aging % Strength Retain	85	85	100	97	97			-	-	-	-	90	100
Tensile Strength (PSI)	1,200	1,200	1,650	1,600	1,600			1,540	1,574	1,574	1,540	-	1,750
Breaking Strength (Lbf)	-	-	-	-	-			-	-	-	-	90	-
Low Temperature Flexibility	Pass	Pass	Pass	Pass	Pass			-	-	-	-	Pass	Pass
Elongation at Break (%)	210	210	300	295	295			230	267	267	230	240	250
Dimensional Change (%)	2	2	0.5	< 1	< 1			-	-	-	-	1	1
15. Accelerated Weather Resistance	Pass	Pass	Pass	IT	IT			-	-	-	-	Pass	Pass
% Retain Tensile Strength	90	90	100	IT	IT			-	-	-	-	-	100
% Retain Breaking Strength	-	-	-	-	-			-	-	-	-	93	-
minimal tensile PSI	1,260	1,260	1,670	IT	IT			-	-	-	-	-	-
minimal breaking Lbf	-	-	-	-	-			-	-	-	-	91	1,750
16. Ozone Resistance													
no cracks under 7X	Pass	Pass	Pass	Pass	Pass			Pass	Pass	Pass	Pass	Pass	Pass
ASTM D1041 100h													
17. Installed Weight													
PSF w/o Ballast	0.27	0.36	0.30-.40	0.28	0.38	0.28	0.38	0.31-0.34	0.31-0.34	0.31-0.34	0.31-0.34	0.31	0.28
18. Warranty Years	10	10	10	10	10	5+10	5+10	31 (81 mil) 21 (other)	31 (81 mil) 21 (other)	31 (81 mil) 21 (other)	31 (81 mil) 21 (other)	10	10
19. First Year of Service	1979	1980	1963	1980	1980	1964	1964	1979	1965	1982	1965	1979	1981
20. Factory Mutual (FM) Class 1	NA	NA	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	NA	NA
Underwriters Laboratory (UL) Class A	Pass	NA	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

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						Miscellaneous					
Product Name	Alphagard	Geoflex	Tropigard	PIB 1000	PIB Roofing	Nitrile Alloy Bond Greys	Trimeric Polymer Polyester Duro-Last	Polyester Reinforced TPE Fiber Tite	Urethane CPR	Urethane Rimspray	Silcone Impregnated Fiberglass
Supplier	AGR Co.	Republic Powdered Metal	Tropical Industrial	Carboline Company	PIB Roofing Products & Systems	Bondcote System	Duro-Last Roofing Inc.	Seaman Corp.	Duck-Tite CPR Div.	Polymer Development Laboratories	Otto Fabric Inc.
1. Thickness (mm)	-	-	-	1.39	-	-	-	-	-	-	-
ASTM D374 (mils)	100	100	100	-	120	35	40	36	25	50	29
2. Tensile Strength (PSI)	-	-	-	-	-	7,500	-	8,590	7,000	2,270	20,000
ASTM D412 (PSI)	550	550	500	380	556	-	-	-	-	-	-
ASTM D751 (lbs)	-	-	-	-	-	-	390x390	375x350	-	-	-
Breaking Strength (Lbf)											
3. Lab Joint Strength	-	NA	-	-	NA	NA	NA	-	NA	NA	NA
ASTM D412 (%)											
ASTM D751 (%)	159.5 Lbf	-	159.5	-	-	-	-	> 300 lb	-	-	-
Before exposure (Lbf)	-	-	-	72	-	-	-	-	-	-	-
After exposure (Lbf)	-	-	-	72	-	-	-	-	-	-	-
After immersion (%)	-	-	-	99	-	-	-	-	-	-	-
4. Elongation at Break (%)	410	410	410	550	410	NA	28	20 warp	420	NA	280
ASTM D412								30 fill			
ASTM D1682											
5. Tensile Set %	-	NA	-	10	NA	NA	NA	NA	-	NA	NA
ASTM D412											
ASTM D395	91.5	-	91.5	-	-	-	-	-	-	-	-
6. Low Temperature Flexibility	-40°F	-40°F	-40°F	Pass	-40°F	Pass	-30°F	-30°F	-85°F	-30°F	-80°F
ASTM D746	Pass	-	Pass	-	-	-	Pass	Pass	-	-	-
ASTM D2138 1/8" Mandrel	-	-	-	-	-	-	-	-	-	-	-
7. Water Absorption	-	-	-	-	NA	NA	NA	NA	-	NA	NA
Change in mass	0.032	0.032	0.032	< 2	-	-	-	-	1.6	-	-
ASTM E96 (%)											
Tensile Strength PSI	-	-	-	360	-	-	-	-	-	-	-
Breaking Strength Lbf											
8. Dynamic Impact (Puncturing)	208.4	NA	208.4	Pass	NA	NA	NA	-	Na	NA	NA
Fed. Test 101B Method 2031 Lbs	-	-	-	-	-	-	-	250	-	-	-
9. Tear Resistance (Lbf)	176 lb/in	NA	176 lb/in	NA	NA	NA	NA	100	NA	NA	NA
ASTM D624											
10. Tearing Strength Lbf	(a) 52	92 PLI	(a) 52	NA	NA		-	100	(c)650 PLI	42	NA
ASTM D751	(b)139.4	190 PLI	(b)139.4			100x90	90x90	-	(split) 50PLI	-	-
11. Low Temperature Impact	no cracks	NA	no cracks	NA	NA	NA	NA	Pass	Na	NA	NA
ASTM D746	-30 F		-30°F								
12. Permeability	0.01	0.112 WVT	0.01	NA	NA	0.379	-	-	0.024	0.000153	NA
ASTM E96 g/m²d	Perm.	-	Perm.	-	-	Perm.	0.151	1.3	perm-inch	perm	-
13. Cone Penetration	NA	NA	NA	NA	NA	NA	NA	Pass	NA	NA	NA
DIN 53443											
14. Heat Aging & Strenth Retain	97.7	97.7	97.7	95	97.7	NA	NA	> 95	80	NA	-
Tensile Strength (PSI)	-	-	-	360	-	-	-	-	5,600	-	-
Breaking Strength (Lbf)	-	-	-	-	-	-	-	-	-	-	-
Low Temperature Flexibility	-	-	-	Pass	-	-	-	-	-85°F	-	-
Elongation at Break (%)	-	-	-	100	-	-	-	-	460	-	-
Dimensional Change (%)	-	-	-	2	0.7	-	-	-	-	-	-
15. Accelerated Weather Resistance	15,000 hrs	NA	15,000 hrs	Pass	-	3,000	1,000	5,000	8,000	NA	23,966
% Retain Tensile Strength	-	-	-	95	-	-	-	-	76	-	-
% Retain Breaking Strength	-	-	-	-	-	-	-	-	-	-	-
minimum tensile PSI	-	-	-	360	-	-	-	-	-	-	-
minimum breaking Lbf	-	-	-	-	-	-	-	-	-	-	-
16. Ozone Resistance											
no cracks under 7X	Pass	NA	Pass	Pass	NA	Pass	NA	Pass	Pass	NA	NA
ASTM D1041 100 h											
17. Installed Weight											
PSF w/o Ballast	0.57	0.57	0.57	0.32	0.60	0.22	0.21	0.25	0.147	NA	0.19
18. Warranty Years	10	5 or 10	10	10	20	10	20	10	5/5	NA	10
19. First Year of Service	1950	1960	1950	1968	1982	-	1978	1974	-	1980	1980
20. Factory Mutual (FM) Class 1	Pass	Pass	Pass	Pass	1-90	Pass	Pass	Pass	NA	Pass	Pass
Underwriters Laboratory (UL) Class A	Pass	Pass	Class A&B	Pass	NA	Pass	IT	Pass	NA	Pass	NA

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MODIFIED BITUMENS

Product Name	Tiffany	ABC Standard	ABC Aluminum	ABC Premium	ABC Granular	Sam	Dibiten	Conso-Gard	Conso-Gard II	Glasdan R-16	Esterdan R-16	Glasdav AL-80	Esterdan BM
Supplier	The American Lubricants Co.	American Roofing Corporation				Apache	Bose Co Inc	Cons Prot	Coating Corp	Pamosa Carribbean Inc			
Thickness mils	157	160	160	160	175	75	6	118	157	160	160	160	160
Top Surface	Modified Bitumen	Plain	Aluminum	Plain	Mineral	Polypropylene	-	Plain	Plain	Bitumen	Bitumen	Alum	Mineral Granules
Reinforcement	Polyester	Fiberglass	Fiberglass	Polyester	Polyester	Polypropylene	Polyester	Polyester	Polyester	Glass Fiber	Polyester	Glass Fiber	Polyester
Reinforcement	-	-	-	-	-	-	Fiberglass						
Installed Weight PSF	0.82	0.88	0.88	0.88	0.96	0.60	0.89	0.60	0.90	0.77	0.77	0.77	0.77
1. Breaking Strength													
Grade 1-Min. 66 lbf (294N)	-	111	106	164	158			67.2	-	*	-	*	-
Grade 2-Min. 176 lbf (785N)	208	111	106	164	158			-	-	-	*	-	*
2. Ultimate Elongation (Elongation at Break)													
Grade 1-Min. 4.0%	-	38	40	58	89			15	-	*	-	*	-
Grade 2-Min. 8.0%	72.38	38	40	58	89			-	-	-	*	-	*
3. Load Strain Product [Break Strength (N) x Ultimate Elongation (%)]													
Grade 1-If breaking strength is not met; 19400	-	-	-	-	1			-	-	-	-	-	-
Grade 1-If breaking strength is met; 2940	-	18,770	18,840	42,300	62,600			-	-	-	-	-	-
Grade 2-Min. 14700	-	18,770	18,840	42,300	62,600			-	-	*	*	*	*
4. Water Resistance													
Shall not absorb more than 1.0g of water	0.0	< 1.0	< 1.0	< 1.0	< 1.0			NIL	-	*	*	*	-
Dimensional change shall not exceed ±1.0%	1.0	< 1.0	< 1.0	< 1.0	< 1.0			NIL	-	-	-	-	-
5. Low Temp Flexibility - 4 out of 5 samples will pass water tightness test						NOT AVAILABLE	NOT AVAILABLE						
Type 1-After testing at -22°F (-30°C) (Pass/Fail)	-	Pass	Pass	Pass	Pass			Pass	-	-	-	Pass	-
Type 2-After testing at -14°F (-10°C) (Pass/Fail)	Pass	Pass	Pass	Pass	Pass			-	Pass	Pass	Pass	-	Pass
6. Water Vapor Transmission													
Max. 1.0g/m² x 24h	0.06	0.132	0.132	0.132	0.132			-	-	6.29	6.29	3.42	9.17
7. Thermal Stability													
Type 1, Class B only-Expansion or concentration less than 1 mm/m between 10 and 30 cycles	-	NA	IT	NA	NA			-	-	NA	NA	NA	NA
8. Dynamic Impact (Puncturing)													
Pass water tightness test after energy impact of:													
Grade 1 - 1.8 ft. (2.45J)(Pass/Fail)	-	***						Pass	-	-	-	Pass	-
Grade 2 - 3.6 ft. lbf (4.9J)(Pass/Fail)	Pass	Pass	IT	Pass	Pass			-	Pass	Pass	Pass	-	Pass
9. Static Puncturing													
Type 1 - After 1 hr. at 55 lbf (245N) shall pass water tightness test (Pass/Fail)	Pass	Pass	Pass	Pass	Pass			Pass	Pass	-	-	-	-
10. Lap Joint Strength													
5 Day Conditioning													
Grade 1-Min. 66 lbf (294N)	-	168	84	128	168			-	-	*	*	*	-
Grade 2-Min. 176 lbf (785N)	166.32	168	84	128	168			-	-	-	-	-	*
Grade 1&2-Pass Water tightness test (Pass/Fail)	Pass	Pass	Pass	Pass	Pass			-	-	Pass	Pass	Pass	Pass
Immersion at 50°C for 5 Days													
Grade 1-Min. 66 lbf (294N)	-	144	99	155	140			-	-	*	*	*	*
Grade 2-Min. 176 lbf (785N)	176.8	144	99	155	140			-	-	-	-	-	-
Grade 1&2-Pass water tightness test (Pass/Fail)	Pass	Pass	Pass	Pass	Pass			-	-	Pass	Pass	Pass	Pass
Immersion at 50°C for 5 Days Plus Freeze Thaw Cycles													
Grade 1-Min 66 lbf (294N)	-	145	95	155	164			-	-	*	*	*	*
Grade 2-Min 176 lbf (785N)	175.48	145	95	155	164			-	-	-	-	-	-
Grade 1&2-Pass water tightness test (Pass/Fail)	Pass	Pass	Pass	Pass	Pass			-	-	Pass	Pass	Pass	

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Product Name	Tiliany	ABC Standard	ABC Aluminum	ABC Premium	ABC Granular	[illegible]	Bibiten	[illegible]-Gard	[illegible]-Gard II	[illegible]adan R-36	Esterdan R-36	Glasdan AL-80	Esterdan BM
11. Granule Embedment													
Class A Only - Max. 0.5 g loss	-	NA	NA	NA	0.41 g/cm²			-	-	NA	NA	NA	-
12. Accelerated Weathering													
Type 1 Only - after prescribed no. of cycles (approx. 90 days)													
Shall not show cracking or blistering (Pass/Fail)	Pass	IT	IT	IT	IT			-	-	Pass	Pass	Pass	Pass
Retain 90% of breaking strength, Test 1	189.69	IT	IT	IT	IT			-	-	-	-	-	-
Retain 90% of elongation at break, Test 2	66.15	IT	IT	IT	IT			-	-	-	-	-	-
13. Crack Bridging Capability													
Shall show no cracking, splitting or loss of adhesion													
Type 1.a and 1.b at -22°F (-30°C) (Pass/Fail)	-	IT	IT	IT	IT			-	-	-	-	-	-
Type 2.a and 2.b at -14° (-10°C) (Pass/Fail)	Pass	IT	IT	IT	IT			-	-	-	-	-	-
Warranty Years	5+5	10	10	10	10	5+5	10	10	10	10	10	10	10
First Year of Service	1967	1968	1968	1968	1968	1979	1969	-	-	1979	1979	1979	1979
Underwriters Laboratory (UL)	Pass	Pend	Pend	Pend	Pend	IT	-	-	-	-	-	-	-
Factory Mutual (FM)	Pass	-	-	-	-	IT	Pass	-	-	-	-	-	-

* Tested under ASTM
Not available CGSB Standard 37-GP-56M

MODIFIED BITUMENS

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Product Name	Paradiene-20	Rhoflex	Mighty Plate	Bras SP4	GRM-120	GRM-230	GRM-350	GRM-500	SD-4	EDIL SPM	Phralon MT4	KMM Aluminum Membrane	KMI Standard Membrane
Supplier	Siplast Inc.	Teltex Inc.	Texas Refinery Corp.	U.S. Intec	----W. R. Grace Company-----------			Belzoof Intl. Inc.		EDIL	Impreltalia S.P.A.	Koppers Co., Inc.	
Thickness mils	90	160	157	150	50	50	50	50	150	160	160	120	160
Top Surface	Plain	Optional	Mod. Bitumen	-	Polyethylene	Polyethylene	Poly-ethylene	Polyvinyl Fluoride	-	-	-	Alum. Foil	-
Reinforcement	Glass Mat	Polyester	Polyester Fabric	Polyester	Alum. Foil	-	-	Poly-ethylene	Polyester	Polyester	Polyester	Poly-ethylene	Poly-ethylene
Reinforcement	-	-	Non Woven	-	-	-	-	Alum. foil	Non-woven	-	-	-	-
Installed Weight PSF	0.48	0.88	0.82	0.88	0.34	0.34	0.34	0.34	0.82	0.88	0.78	0.63	0.80
1. Breaking Strength													
Grade 1-Min. 66 lbf (294N)	72	-	-	-	102	102	51	150	450 psi	550 psi	500 psi	300 psi	100 psi
Grade 1-Min. 176 lbf (785N)	-	-	208	208	-	-	-	-	-	-	-	-	-
2. Ultimate Elongation (Elongation at Break)													
Grade 1-Min. 4.0%	29	57	-	-	210	169	215	164	50	50	50	200	300
Grade 2-Min. 8.0%	-	-	72.38	72.38	-	-	-	-	-	-	-	-	-
3. Load Strain Product [Break Strength (N) x Ultimate Elongation (%)]													
Grade 1-If breaking strength is not met; 19400	-	-	-	-	-	-	49,000	-	-	-	-	-	-
Grade 1-If breaking strength is met; 2940	9,393	-	-	-	95,550	76,900	-	109,700	-	-	-	-	-
Grade 2-Min. 4700	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Water Resistance													
Shall not absorb more than 1.0g of water	0.30	-	0.0	0.0	0.04	0.04	0.8	0.07	-	-	-	-	-
Dimensional change shall not exceed ± 1.0%	-	-	1.0	1.0	0.0	0.0	0.0	0.0	-	-	-	-	-
5. Low Temp Flexibility - 4 out of 5 samples will pass water tightness test													
Type 1-After testing at -22°F (-30°C)(Pass/Fail)	-	-	-	-	Pass	-	-	Pass	-40°F	0°F	14°F	14°F	14°F
Type 2-After testing at -14°F (-10°C)(Pass/Fail)	Pass	-	Pass	Pass	-	Pass	Pass	-	-	-	-	-	-
6. Water Vapor Transmission													
Max. 1.0g/m² x 24 h	-	0.78	0.06	0.06	-	-	-	-	-	-	-	-	-
7. Thermal Stablity													
Type 1, Class B Only - Expansion or contraction less than 1 mm/m between 12 and 30 cycles	NA	NA	-	-	-	-	-	-	-	-	-	-	-
8. Dynamic impact (Puncturing) Pass water tightness test after energy impact of:													
Grade 1 - 1.8 ft. lbf (245J) (Pass/Fail)	-	-	-	-	-	-	-	-	-	-	-	-	-
Grade 2 - 3.6 ft. lbf (4.9J) (Pass/Fail)	-	-	Pass	Pass	-	-	-	-	-	-	-	-	-
9. Static Puncturing													
Type 1 - After 1 hr. at 55 lbf (245N) shall pass water tightness test (Pass/Fail)	Pass	-	Pass	Pass	-	-	-	-	-	-	-	-	-
10. Lap Joint Strength													
5 Day Conditioning													
Grade 1-Min. 66 lbf (294N)	74	-	-	-	93	93	81	104	-	-	-	-	-
Grade 2-Min. 176 lbf (785N)	-	-	166.32	166.32	-	-	-	-	-	-	-	-	-
Grade 1&2-Pass water tightness test (Pass/Fail)	Pass	-	Pass	Pass	Pass	Pass	Pass	Pass	-	-	-	-	-
Immersion at 50°C for 5 Days													
Grade 1-Min. 66 lbf (294N)	-	-	-	-	121	121	90	121	-	-	-	-	-
Grade 2-Min. 176 lbf (785N)	-	-	176.8	176.8	-	-	-	-	-	-	-	-	-
Grade 1&2-Pass water tightness test (Pass/Fail)	-	-	Pass	Pass	Pass	Pass	Pass	Pass	-	-	-	-	-

Product Name	Paradiene-20	Nhoflex	Mighty Plate	Bral SP4	GRM-120	GRM-230	GRM-150	GRM-500	SD 6	EDIL SPM	Phralon NT4	KMM Aluminum Membrane	KMM Standard Membrane
10. (Continued) Immersion at 50°C for 5 Days Plus Freeze Thaw Cycles													
Grade 1-Min. 66 lbf (294N)	-	-	-	-	-	-	-	-	-	-	-	-	-
Grade 2-Min. 176 lbf (785N)	-	-	175.48	175.48	-	-	-	-	-	-	-	-	-
Grade 1&2-Pass water tightness test (Pass/Fail)	-	-	Pass	Pass	-	-	-	-	-	-	-	-	-
11. Granule Embedment Class A Only-Max. 0.5 g loss	NA	-	-	-	-	-	-	-	-	-	-	-	-
12. Accelerated Weathering Type 1 Only-after prescribed no. of cycles (approx. 90 days)													
Shall not show cracking or blistering (Pass/Fail)	NA	-	Pass	Pass	-	-	-	-	-	-	-	-	-
Retain 90% of breaking strength, Test 1	NA	-	189.69	189.69	-	-	-	-	-	-	-	-	-
Retain 90% of elongation at break, Test 2	NA	-	66.15	66.15	-	-	-	-	-	-	-	-	-
13. Crack Bridging Capability Shall show no cracking, splitting or loss of adhesion													
Type 1.a and 1.b at -22°F (-30°C)(Pass/Fail)	-	-	-	-	Pass	-	-	Pass	-	-	-	-	-
Type 2.a and 2.b at -14°F (-10°C)(Pass/Fail)	-	-	Pass	Pass	-	Pass	Pass	-	-	-	-	-	-
Warranty Years	16	10+5	5+5	12	10	10	10	10	10	5+5	10	10	5+5
First Year of Service	1968	1970	1967	1961	1979	1975	1971	1980	1982	1982	1980	1963	1963
Underwriters Laboratory (UL)	-	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pend.	Pend.	NA	-	Class A
Factory Mutual (FM)	-	IT	Pass	Pass	Pass	Pass	-	Pass	Pend.	Pend.	NA	Pass	-

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Product Name	Stressply	Pitchply	Hey 'Di ECB	Hyldadinoe	Duralasta P	Duralasta N	Aquashield 2001 AD	Royal Single Ply	Veral (Aluminum Faced)	Veral (Stain/Steel)	Veral Copper	Parafor-50	Paradiene-30
Supplier	The Garland Co., Inc.		Hey Di UFM Corp.	Hyload Inc.	The Kimmenade Corp.		J&P Petrol. Products	Royal Oil Co.	---Siplast Inc.---				
Thickness mils	80	60	83	150	160	160	60	157	130	130	130	150	95
Top Surface	-	-	-	Black	Optional	Slatechip	-	Mod Bitumen	Aluminum	Stain/Steel	Copper	Mineral	Mineral
Reinforcement	2 plies	Unreinforced	Non-Woven	Dispersed	Polyester	Polyester	Polyester	Polyester	Glass Scrim	Glass Scrim	Glass Scrim	Polyester	Polyester
Reinforcement	Wovenglass	-	Fiberglass	Fiber	-	Polyester	Polyester	Non Woven	-				
Installed Weight PSF	1.65[a]	1.50[a]	0.50	0.40	1.0	1.0	0.80	0.82	0.80	0.86	0.86	1.47	0.77
1. Breaking Strength													
Grade 1-Min. 66 lbf (294N)	318	247		247			-	-	139	677	139	164	91
Grade 2-Min. 176 lbf (785N)	318	247		247			-	208	-	-	-	-	-
2. Ultimate Elongation (Elongation at Break)													
Grade 1-Min. 4.0%	340	100		100			-	-	4.0	3.0	4.0	40	24
Grade 2-Min. 8.0%	340	100					-	72.38	-	-	-	-	-
3. Load Strain Product [Break Strength (N) x Ultimate Elongation (%)]													
Grade 1-If breaking strength is not met; 19400	-	-		132,000			-	-	-	-	-	-	-
Grade 1-If breaking strength is met; 2940	14,170	132,000						-	3,613	9,039	3,557	65,392	9,801
Grade 2-Min. 14700	14,170	-		132,000			-	-	-	-	-	-	-
4. Water Reisstance													
Shall not absorb more than 1.0g of water	NA	0.051	NOT AVAILABLE	0.051			-	0.0	0.10	0.10	0.10	0.25	0.23
Dimensional change shall not exceed ±1.0%	NA	-0.5		0.5	NOT AVAILABLE	NOT AVAILABLE	0.25	1.0	-	-	-	-	-
5. Low Temp Flexibility - 4 out of 5 samples will pass water tightness test													
Type 1-After testing at -22°F (-30°C)(Pass/Fail)	NA	NA		Fail			-	-	-	-	-	-	-
Type 2-After testing at -14°F (-10°C)(Pass/Fail)	NA	NA		Pass			Pass	Pass	-	-	-	-	-
6. Water Vapor Transmission Max. 1.0g/m² x 24h	NA	0.5		IT			-	0.6	-	-	-	-	-
7. Thermal Stability Type 1, Class 3 Only - Expansion or contraction less than 1 mm/m between 10 and 30 cycles	NA	NA		IT			-	-	-	-	-	-	-
8. Dynamic Impact (Puncturing) Pass water rightness test after energy impact of:													
Grade 1 - 1.8 ft lbf (245J) (Pass/Fail)	NA	NA		IT			-	-	-	-	-	-	-
Grade 2 - 3.6 ft lbf (4.9J) (Pass/Fail)	NA	NA		IT			Pass	Pass	-	-	-	-	-
9. Static Puncturing Type 1 - After 1 hr. at 55 lbf (245N) shall pass water tightness test (Pass/Fail)	NA	NA		NA			Pass	Pass	Pass	Pass	Pass	Pass	Pass
10. Lap Joint Strength													
5 Day Conditioning													
Grade 1-Min. 66 lbf (294N)	NA	NA		IT			-	-	169	169	169	161	70
Grade 2-Min. 176 lbf (785N)	NA	NA		IT			-	166.32	-	-	-	-	-
Grade 1&2-Pass water tightness test (Pass/Fail)	NA	SA		IT			Pass	Pass	Pass	Pass	Pass	Pass	Pass
Immersion at 50°C for 5 Days													
Grade 1-Min. 66 lbf (294N)	NA	NA		IT			-	-	-	-	-	-	-
Grade 2-Min. 176 lbf (785N)	NA	NA		IT			-	176.8	-	-	-	-	-
Grade 1&2-Pass water tightness test (Pass/Fail)	NA	NA		IT			Pass	Pass	-	-	-	-	-
Immersion at 50°C for 5 Days Plus Freeze Thaw Cycles													
Grade 1-Min. 66 lbf (294N)	NA	NA		IT			-	-	-	-	-	-	-
Grade 2-Min. 176 lbf (785N)	NA	NA		IT			-	175.48	-	-	-	-	-
Grade 1&2-Pass water tightness test (Pass/Fail)	NA	NA		IT			Pass	Pass	-	-	-	-	-

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Product Name	Stressply	Pitchply	Hey 'Di ECR	Hyldrdisoe	Duralasta P	Duralasta M	Aquashield 2001 AD	Royal Single Ply	Veral (Aluminum Faced)	Veral (Stain/Steel)	Veral Copper	Parafor-50	Paradiene-30
11. Granule Embedment													
Class A Only - Max. 0.5 g loss	NA	NA		IT			NA	-	NA	NA	NA	< 1.0	< 1.0
12. Accelerated Weathering													
Type I Only - after prescribed no. of cycles (approx. 90 days)													
Shall not show cracking or blistering (Pass/Fail)	Pass	Pass		IT			NA	Pass	-	-	-	-	-
Retain 90% of breaking strength, Test 1	NA	NA		IT			NA	189.69	-	-	-	-	-
Retain 90% of elongation at break, Test 2	NA	NA		IT			NA	66.15	-	-	-	-	-
13. Crack Briding Capability													
Shall show no cracking, splitting or loss of adhesion													
Type 1.a and 1.b-at -22°F (-30°C)(Pass/Fail)	NA	NA		NA			-	-	-	-	-	-	-
Type 2.a and 2.b-at -14°F (-10°C)(Pass/Fail)	NA	NA		IT			NA	Pass	-	-	-	-	-
Warranty Years	10	10	10	10	10	10	10	5+5	10	10	10	10	10
First Year of Service	1978	1965	1964	1965	1978	1978	1967	NA	NA	NA	NA	NA	1968
Underwriters Laboratory (UL)	Pass	Pass	-	Pass	-	-	NA	Pass	-	-	-	-	-
Factory Mutual (FM)	Pass	Pass	Pass	Pass	-	-	NA	Pass	-	-	-	-	-

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[a] Includes gravel.

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Product Name	**Rhinohide**	**Derbigum**	**Awaplan**	**Poly 4**
Supplier	Monroe, Inc.	Owens Corning Fiberglass Corp.	Tamko Asphalt Products Inc.	Nord Bitumi
Thickness Mils	160	160	160	4
Top Surface	-	-	-	-
Reinforcement	Polyester or Glass	Glass FibreMat Polyester	Polyester	Non-Woven Polyester
Reinforcement				
Installed Weight PSF	0.78	1.0	1.05	-
1. Breaking Strength				
Grade 1-Min. 66 lbf (294N)	500 psi	200 psi	130 PSI	84 Kg/5cm
Grade 2-Min. 176 lbf (785N)	-	-	-	-
2. Ultimate Elongation (Elongation at Break)				
Grade 1-Min. 4.0%	50	30	50	55
Grade 2-Min. 8.0%	-	-	-	-
3. Load Strain Product [Break Strength (N) x Ultimate Elongation (%)]				
Grade 1-If breaking strength is not met; 19400	-	-	-	-
Grade 1-If breaking strength is met; 2940	-	-	-	-
Grade 2-Min. 14700	-	-	-	-
4. Water Resistance				
Shall not absorb more than 1.0g of water	-	2.5	-	-
Dimensional change shall not exceed ± 1.0%	-	2	-	-
5. Low Temp Flexibility - 4 out of 5 samples will pass water tightness test				
Type 1-After testing at -22°F (-30°C)(Pass/Fail)	-14°F	+6°F	0°F	-
Type 2-After testing at -14°F (-10°C)(Pass/Fail)	-	-	-	-
6. Water Vapor Transmission				
Max. 1.0g/m² x 24h	-	0.026	-	0.1
7. Thermal Stability				
Type 1, Class B Only-Expansion or contraction less than 1 mm/m between 10 and 30 cycles	-	-	-	-
8. Dynamic Impact (Puncturing)				
Pass water tightness test after energy impact of:				
Grade 1 - 1.8 ft lbf (2.45J) (Pass/Fail)	-	Pass	-	-
Grade 2 - 3.6 ft. lbf (4.9J) (Pass/Fail)	-	-	-	-
9. Static Puncturing				
Type 1 - After 1 hr. 15 55 lbf (245N) shall pass water tightness test (Pass/Fail)	-	-	-	-
10. Lap Joint Strength				
5 Day Conditioning				
Grade 1-Min. 66 lbf (294N)	-	200 lb/in	-	-
Grade 2-Min. 176 lbf (785N)	-	-	-	-
Grade 1&2-Pass water tightness test (Pass/Fail)	-	-	-	-
Immersion at 50°C for 5 Days				
Grade 1-Min. 66 lbf (294N)	-	-	-	-
Grade 2-Min. 176 lbf (785N)	-	-	-	-
Grade 1&2-Pass water tightness test (Pass/Fail)	-	-	-	-
Immersion at 50°C for 5 Days Plus Freeze Thaw Cycles				
Grade 1-Min. 66 lbf (294N)	-	-	-	-
Grade 2-Min. 176 lbf (785N)	-	-	-	-
Grade 1&2-Pass water tightness test (Pass/Fail)	-	-	-	-

TABLE 10 (Concluded)

Product Name	Rhinohide	Derbigum	Awaplan	Poly 4
11. Granule Embedment				
Class A Only-Max. 0.5g loss	-	-	-	-
12. Accelerated Weathering				
Type 1 Only-after prescribed no. of cycles (approx. 90 days)				
Shall not show cracking or blistering (Pass/Fail	-	Pass	-	-
Retain 90% of breaking strength, Test 1	-	-	-	-
Retain 90% of elongation break, Test 2	-	-	-	-
13. Cracking Briding Capability				
Shall show no cracking, splitting or loss of adhesion				
Type 1.a and 1.b at -22°F (-30°C) (Pass/Fail)	-	-	-	-
Type 2.a and 2.b at -14° (-10°C) (Pass/Fail)	-	-	-	-
Warranty Years	10	10	5+5	5+5
First Year of Service	1979	1968	1973	1967
Underwriters Laboratory (UL)	Pend.	Class A,B&C	Class A	NA
Factory Mutual (FM)	Pass	Pend.	Class 1	NA

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WATERPROOFING AND THE "FREEZE-THAW" CYCLE

By Benjamin Cinquina

Webster's definitions: Adjective - "Impervious to water". Verb transitive - "To make impervious to water".

This is an ideal, not obtainable - at best, a very limited time. It will become apparent to those who choose to view from a wise vantage point, that a lot less than waterproof is practical.

May I direct your attention to a point of view that will prove to afford the maximum effect from efforts to render things waterproof. Please refer to the American Society of Heating, Refrigerating and Air-Conditioning Engineers' (A.S.H.R.A.E.) manual's chapter on Moisture in Building Construction.

Water vapor, moist air, is present practically everywhere. The effects of waterproofing with respect to roofing has been covered by your colleague Mark D. Langford.

Let us consider the effects of water and water vapor encountered by all of us, other than roofing. Three main classifications of water sources are ground, surface and atmospheric. Three states of water are ice, water and water vapor. Three forces for water movement are static, dynamic and hygroscopic.

Building construction of most universities and colleges are mostly concrete, stone or brick masonry, and curtain wall. Foundation walls are below grade to a minimum of the local frost line, while some extend one or more floors below grade as basements, sub-basements and so on.

To ensure "waterproof" construction, the foundation must be of monolithic construction and of concrete or masonry with joints that will remain dimensionally stable, so as not to present openings, or cracks through which ground water can pass.

To ensure no water passage because of porosity, a waterproofing material such as asphalt or coal tar pitch is applied to the water-exposed side of the wall. There are a number of more elaborate combinations of waterproofing materials - a layer of 4.0 mil. thick polyethylene is applied over a first coat of asphalt, then second application of asphalt. Also, a number of waterproofing boards can be applied to the below grade wall, including Bentonite, a hygroscopic mineral that swells when wetted sealing off cracks. If disturbed and fully expanded, waterproofing will be lost.

It is in the process of waterproofing wherein a subsoil drainage system was employed which gave way to the logic of "Controlled water". After "sealing of the foundation outlined above a system of very porous gravel around drainage tile is used to carry ground water away from the foundation to a lower point drain. The first systems were simply ungrouted jointed vitreous clay drain tile piping. This led to the manufacture of preforated tile, which carried over to the avalanche of plastic pipe - PVC's - corrugated, etc.

Note that the system "works" by carrying away the ground water, reducing hydrostatic pressure to a point below forcing water through minute cracks, openings, etc. On relatively low height buildings of one or two stories high, a roof overhang, together with landscape grading away from the foundation can keep most precipitation from penetrating the ground close to the foundation. Not so on high-rise buildings or during the occasional wind-driven rains and snows.

Please notice the two factors previously presented casually. The construction must be 1) stable - no marked expansion and contraction and, 2) the water is "controlled".

Of the three forces, ground water is hydrostatic and controlling of this water is as simple as a drainage system. Remember this principle, "Controlled water", as we progress through the spectrum of buildings' construction.

Without a stable structure, no amount of waterproofing and drainage will remain effective. Many very old buildings have a "dry" lime mortared field stone foundation. Many were not set on stable soil and/or not set below the frost line. Underpinning can be a very costly operation, and is usually only employed for historic buildings or other considerations rather than life expectancy and/or "payback".

The floors on grade of basement/below grade construction present another complimentary condition to the foundation walls. Again, they must be structurally sound, or made so. The best "controlled water" systems consist of an exterior foundation drain tile system, set upon the top of the spread footer on the exterior of the wall, while a second drain tile system is set in the gravel bed beneath the floor slab. This system collects and carries away any ground water not drained by the exterior system before it can rise above the level of the bottom of the floor slab.

All well designed concrete slab floors on earth, at grade, or below grade will have a polyethylene vapor barrier film between the gravel base and the underside of the concrete slab.

Existing buildings with concrete floors not placed upon a vapor barrier will almost always permeate moisture through them in varying degrees that can disturb any resilient floor coverings applied.

If it is desired to place resilient floor covering on an existing concrete slab on or below grade, and it is questionable if there is a vapor barrier, or if a known vapor barrier is ineffective, a simple test will determine if moisture is passing upward through the slab.

A test sheet of 4.0 mil. polyethylene, approximately 4 feet square is laid directly on the floor and covered with plywood or masonite for 24 to 48 hours. As many areas as are needed to determine the total extend must be tested.

If moisture is permeating the concrete, it will form droplets of water beneath the plastic, and or the concrete will be darkened by moisture in this area. If a kitchen match will not immediately "strike" or blackboard chalk will not readily mark without "dragging", it is probably dry enough for direct floor covering.

Of course, this test should be performed during any normal wet season of the year, or for several days after heavy precipitation.

If you want to apply floor covering and you know no vapor barrier exists, or the test shows water vapor passing through the slab, consider placing 4.0 mil. or 6.0 mil. polyethylene on an asphaltic adhesive over the existing floor slab and then a new concrete topping, a minimum of 3 inches thick reinforced with lightweight road mesh.

Should a wood floor be desired, lay the polyethylene on an ashpalt mastic and set treated wood sleepers into mastic onto the polyethylene. Pour a lightweight concrete fill using expanded shale aggregate such as Haydite between the sleepers. Apply a second layer of polyethylene and fasten treated plywood subfloor to the sleepers with nonferous nails. 30 pound roofing felt is then laid down and any wood strip finish floor can be laid or even a parquette finish floor can be applied, usually set in an asphaltic cement with a few concealed nails in the tongue of the flooring. Be sure to allow for thermal expansion at all edges of each layer or sleepers, subfloor and finish floor.

New construction should have all slabs on grade, footers and foundations soil, subgrade poisoned with an approved insecticide to prevent termite infestation.

Existing slabs must have about one inch hammer-drilled holes to subsoil and saturated with insecticide, such as chlordane, before any other construction is started. Fill the resultant holes with a seal of asphalt or coal tar pitch to the bottom of the slab, and final-patch with a non-shrink cement mortar to finish level.

Buildings constructed over crawl spaces present a unique condition and can be handled as follows. The best method is to install a concrete slab over a vapor barrier placed on granular fill, such as pea-gravel. Concrete can be placed by using suitable concrete pumps with a flexible distribution hose. These pumps require a smooth washed river gravel aggregate. Crushed rock aggregate concrete cannot be pumped due to the sharp edges of the stones.

If concrete is deemed too costly, or too difficult to place and finish because of headroom restrictions, the minimum of 4 inches of pea-gravel should be placed on grade, 6.0 mil. polyethylene placed over the leveled bed, joints sealed with asphaltic mastic as well as all perimeter edges sealed to the foundation walls plus any penetrations, such as piping, conduit, etc. A final protective 4 inch minimum layer of pea-gravel is put in place to allow maintenance work without damage to the plastic.

Again, the soil and foundation must be chemically treated against termite infestation. Extreme caution must be exercised for installing workmen. Personal air-pacs must be employed along with protective clothing. An alternate would be to provide a "push pull" ventilation system with supply and exhaust fans sized to provide 15 air changes per hour, or one air change every 4 minutes. This is easily calculated by determining the volume of the work area, length x width x height in feet equals cubic foot volume, divided by 4 minutes per each air change equals cubic feet per minute, C.F.M. air capacity of both the air supply "push" fan and the air exhaust "pull" fan, or fans. The objective is to poison the ground, and not the workers.

Through A.S.H.R.A.E., the University of Illinois has documented proof that more water vapor can be released by exposed earth in a crawl space than if the crawl space were a pool of water. The granules of earth provide many times the surface area for release of water vapor by capillary action than does a flat pool of water. Space temperature is also a determining factor in the speed of water vapor movement.

Crawl spaces are best sealed as described above and any old ventilation openings closed off. The foundation walls should be insulated with a closed cell polystyrene foam insulation to retard heat loss. Polystyrene pellets, compressed into "bead board foam" insulation is a far cry from quality closed cell polystyrene, and is not recommended for below grade or crawl space insulation.

Often times, glass fiber or glass wool "Batt" insulation is installed between floor joists over a crawl space. This is good as it retards heat loss through the floor to the cooler crawl space, and raises the floor surface temperature, but in no way provides any heat or warmth of itself, here or in any other type of insulation application, a common missunderstanding.

There is documented evidence of the complete destruction of metal bar joists and collapse of the supported floor due to rusting of metal floor joists over an untreated crawl space, and/or rotting of wood structures.

We now move up to above grade wall construction. Masonry, wood, metal siding, and the many, many combinations of these materials.

Before the need for energy conservation became so urgent, so called "good" wall construction was masonry face brick with unit masonry back-up, furring strips and lath and plaster, drywall, panelling, etc. with the ever broadening use of air conditioning many things were studied and new criteria developed to eliminate the mistakes of the past.

Some old historic masonry walls are of solid "soft" brick and lime mortar. Very stable, massive, etc., and they would soak up precipitation to some point within the thickness of the wall, and then simply dry out in reverse as the sun shone and winds blew, with no problems to the interior finishes, such as direct applied gypsum plasters.

With the advent of hard face bricks, concrete block back-up and so on, the walls are less massive, less adsorbent and so on. With heavy wind driven rains, water is forced through movement cracks and gets into or is blown through wall openings, causing great havoc.

The furring system of lath and plaster was used to prevent gypsum plaster or drywall from becoming wet, which destroys any gypsum material.

If there are many and/or large masonry cracks, these must be repaired by tuck-pointing with new mortar after carefully preparing the cracks by chipping, etc. If there are many cracks over a broad area, you must first treat the structural problem before repairs can be expected to remain permanent.

Even the best designed masonry with calculated and executed control joints, will crack. Poured reinforced concrete will crack by its very nature of shrinkage. For new or replacement concrete, consider the "Chem-Comp" type concrete, with limited, controlled expansion. Where no control joints are present, or existing one did not prevent cracking, new control joints should be made. With a masonry saw, cut a 3/8 inch wide joint, the thickness of the face brick between cracked wall areas, to allow for controlled movement. Place closed cell foam insulation rope called "backer-rod" the full depth of the cut joint to within 1/4 to 3/8 inch deep from the surface. Place a quality two or three part elastomeric or rubber caulking compound into the joint, tooling-off for a finished appearance. Follow manufacturers instructions for preparing the surfaces, priming sides for proper adhesion and done only on dry days of the recommended temperature range. The caulking must be half as thick as the 3/8 inch joint width to permit lateral expansion of a low mass of caulking without causing failure of the bond to each side of the cut joint.

We emphasize quality caulking. Filling of existing irregular masonry cracks with caulking in lieu of proper preparation and tuck-point almost always results in complete failure.

Cracking in masonry walls is largely the result of the "Freeze-Thaw" Cycle, where water is admitted through a structural failure and is entrapped where the temperature drops and the water freezes, expanding as it does so. The tremendous force of the expansion of freezing water cannot be contained and something has to "give".

We mentioned earlier, waterproofing to prevent entry of water into structures is best accomplished by controlling the water rather than preventing water entry, an assured impossibility.

Controlling water is best accomplished by forming a wind screen. Water entry through vertical surfaces is forced into cracks by wind pressure and/or barometric pressure differential. Masonry cavity walls are constructed so that the face brick forms a wind screen. After the water enters the brick and mortar cracks, it is "controlled" in that it now runs down the back side of the brick within the cavity to the bottom of the wall, where through wall flashing and weep holes allows the water to exit harmlessly.

For concrete or brick or quarry tile patio roofs, the waterproof membrane is placed upon the structural slab and carried to the weep holes of the area drains, directing leaking water through masonry and mortar cracks harmlessly away before it can freeze and create havoc.

Again, structual problems must be corrected, then major cracks properly prepared and patched. Existing expansion joints and new required joints must be made, cleaned, primed and caulked, again, using an aspect ratio of twice the width to the depth of the caulked joint, and no wider than 1/2 inch.

Finally, after flat walks or vertical walls are structurally repaired, and properly tuck-pointed and patched, and properly caulked, a water repellant coating must be applied.

The best, most successful coatings are those which will "bridge" minute cracks, effectively sealing off these cracks, plus sealing the pores of brick and concrete. We have found for most surfaces, a solvent based coating with parafins in suspension work best. The solvent carries the parafins into the pores and cracks, evaporates, and leaves the parafins to bridge over and seal these pores and cracks.

We have worked our way up to tops of buildings very many of which, with flat roofs, have parapet walls, the scourge of the industry.

Here, we have not one, but three surfaces, laden with potential pitfalls, collectively, the most troublesome areas of buildings there is.

They are subjected to the greatest forces, in multiples, tandem, and so forth. There are two vertical surfaces exposed to wind and precipitation. There is no inside warm protected surface. The sun will strike first one side, and after some hours of time, the opposite side. On low ambient air temperature days, there can be extreme temperature differences on either side of a parapet wall, which will alternate within 12 hours.

We all understand different materials have different coefficients of expansion. Thus, adjacent materials, not expanding or contracting at the same rate, or not subject to the same temperature changes will literally tear apart from one another with tremendous shear forces.

If the parapet wall is relatively low, it is often not the full width of the lower heated wall. It will often have formed or cut recesses or reglets to receive counter flashing. The roof side of the wall is very often coated with black roofing materials, full height of the wall. These black materials absorb heat from the sun. They are usually of asphaltic material which dries out in a short time. They are not protected from the sun's ultraviolet rays as is its adjoining mineral or gravel surfaced roofing.

The top of the wall has some sort of coping, of metal, clay tile, preformed or cut stone, or possibly terra cotta. There are joints at various intervals which allow movement and cracks or openings, allowing water to penetrate into wall voids, pocket and freeze. This is perhaps the greatest aggrevation encountered.

Again, you must first make the parapet structurally sound and make previsions for expansion and contraction.

Thermal movement can be considerably reduced by applying reflective coatings rather than black. Coatings should be of the elastomeric types, modified bitumens, or rubber type materials. Old asphalt that is dried, blistered and cracked must be removed.

Repairs of counterflashings and reglets must be properly made by skilled craftsmen.

Copings must be repaired. Old metal should be replaced using proper joints for expansion and contraction. Defective stone or stone like concrete copings must also be repaired or covered with new metal copings. We have removed many stone copings, filled all water holding mortar voids, installed new aluminum, copper or stainless steel metal coping, and reset the stone coping over this. Future failures of stone mortar joints are rendered harmless this way and help stop metal buckling.

Where spalling from past freezing is unsightly, but not structurally weakened severely, cement stucco directly applied upon anchored galvanized metal lath, will afford a cosmetic improvement. This is to be coated with a quality water repellant plain, or tinted to match or contrast with the existing adjacent surfaces.

Many attractive metal sidings are available to both provide the wind screen, and improve the appearance of the surfaces. They are easily flashed and counterflashed with the existing walls.

Careful application will minimize "oil-canning" pops as the moving sun causes expansion and then contraction returns as the sun sets.

Finally, we would emphasize that you first analyze and correct any structural problems. Then perform the necessary repairs, and finally apply quality caulking and water repellants.

Lastly, all of these principles should be dutifully prescribed for any new construction during the most important planning stages, and ensure their explicit execution throughout construction to final completion.

Managing Maintenance Information

By Pieter J. van der Have
University of Utah

Introduction

All types of educational institutions can consider themselves extremely lucky if they can continue to hang on to whatever budget base they have right now. University presidents and similar administrators must be convinced that they are receiving a fair return on their investments. It is ludicrous to go after an increase in the budget base until the existing one can be comfortably explained and justified, even to the most vicious critic.

We decided to develop a system which would help us justify budget level, as well as help us plan and evaluate our individual efforts. We wanted a system which would provide support to: (1) Work Planning (What's in the mill for tomorrow?), (2) Work Control (What are we doing today and how well?), (3) Work Review (What did we do yesterday--can it help us tomorrow?), (4) Cost Accounting (how much is all this costing everybody?).

We wanted to be able to address these questions with accurate summaries and sufficient detail to convince the boss that we know what we're doing. We also needed to reach these goals with minimal inconvenience to the people doing the very work we're evaluating. Finally, we wanted a system flexible enough that we could tie in peripheral programs such as: key control, fleet rentals, and others. Spurred on by a few nudges from auditors and similar beings, we created our INFORMATION RETRIEVAL, MANAGEMENT & ACCOUNTING (IRMA) system. We tried to remember that management should want to walk that thin line between trust and curiosity, and avoid a similar but more tempting course between distrust and inquisition. In designing any information system, such a distinction has to be honored. Let's look at what we came up with after all that theorizing.

Evolution of IRMA

Until we went on our Microdata, we had been locked into a card-oriented system. Over the last fifteen years, we progressed from a totally manual system, to an archaic IBM 402, to a mammoth UNIVAC 1108 (which we shared with students, etc.). The configuration and programs on the 1108 were useful for a long time, but we became increasingly aware of several serious handicaps.

1. Our only vehicle of input was a punched card.

2. We had many (often good) programs which operated independently of each other, had inaccurately duplicated data, and which generated irreconcilable reports.

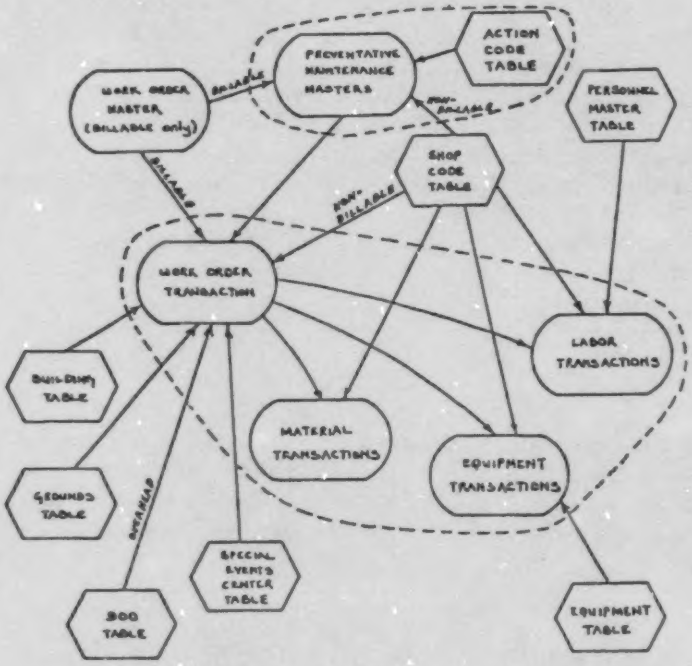
3. Because of the mass of independent programs the system was often inflexible, input was uneditable, and errors which were found were too often uncorrectable.

4. In part due to all of the above, and in part due to us having to share a very large, non-business type computer with higher priority education needs, response was often slow.

Toward the late 70's we started to discuss with the administration the possibility of acquiring a small system dedicated to supporting an overall maintenance management program. Finally in the spring of 1981 we received full approval to proceed with developing the new approach we had been describing so long.

On July 1, 1982, we finally threw out every punched card and related equipment in sight. That date marked the full transfer to our own Microdata. That date marked the end of a gentle period of time when we could blame so many of our woes and troubles on somebody else.

At this moment we are operating with nine CRT's, two printers, one 64 MB disk, and 96K MOS memory. We have operating on the system a labor file, material file, equipment file, preventive maintenance file, and service order, billable work, key control, motor pool, personnel masters, capital renewal replacement files, and a custodial standard file. We have several dozen input and query screens, several dozen formatted reports, and easy generation capabilities for those meaningful "quick-and-dirty" reports.


ACTION CODE TABLE
PREVENTATIVE MAINTENANCE MASTERS
WORK ORDER MASTER (BILLABLE only)
BILLABLE
PERSONNEL MASTER TABLE
NON-BILLABLE
SHOP CODE TABLE
BILLABLE
NON-BILLABLE
WORK ORDER TRANSACTION
LABOR TRANSACTIONS
BUILDING TABLE
MATERIAL TRANSACTIONS
EQUIPMENT TRANSACTIONS
GROUNDS TABLE
OVERHEAD
SPECIAL EVENTS CENTER TABLE
300 TABLE
EQUIPMENT TABLE

Data Collection and Cost

There are certain sets of "fixed" data which have been built in the form of tables within IRMA. The assumption is that these bits of information remain relatively unchanged over a respectable period of time. This allows us to relate the day-to-day activities which we are attempting to measure to a static entity. We have included in these tables a number of fixed tables. (See exhibit on preceding page.)

Visualize, if you will, these main tables surrounding a central core. The nucleus of our IRMA is the work order transaction, which is contained in the work order transaction file. Each work order transaction is unique, and is identified as a unique entity by using the work order number, a card number, and the shop code as an index number. For the file that would have an appearance (generally) like X999, 999999, 9999. For non-billable jobs, the work order number (X999 in the example) consists of two parts. A letter prefix is always the first character in our non-billable (budgeted) work orders. It, along with the shop code (9999 in the above example), has to tie back to defined items in the shop code table. If they don't work a work order can't be issued. The alpha prefix identifies the type of work being performed.

The card number (999999) can be a P.M. "inventory" number relating to items on our P.M. program and is unique for a specific piece of equipment or system. It has to tie back to an item on the P.M. master table. If it doesn't, a work order can't be issued.

If maintenance work is to be performed on a non-P.M. item, the card number is a unique number identifying the sequence of the work order forms. This number is routinely assigned by IRMA. Once a work order has been successfully issued with a unique work order number, card number, and shop code combination, it can't accidentally be issued again with the same combination. This allows us to capture charges on a task-by-task basis.

We have designated the last three characters on the non-billable work order number to relate to either the Building table, or the Grounds table (if the shop code is Grounds') or to the "900" table. We cannot create a work order number if its alpha code does not exist on the pertinent shop code table and/or if the last three digits do not exist on one of the other pertinent tables.

All this could appear to the observer as a whole bunch of time-consuming edits. Admittedly, it would be if it were all done manually. With the computer the edits are performed instantaneously and the work order form is printed by the computer after all the essential data has passed the necessary tests. As the form is being printed, critical information is also written to the disk for instant accessibility. Thus, the data on the work order and on the file are exactly the same!

The "design" of the work order transaction is complex. It has 73 fields of data associated with it. With this record being the main collector of data either immediately or ultimately, and also the main source of output of data, those fields are all essential. The dictionary items allow us to store cost data for current week, prior week, year to date, and estimated (budget) amounts in the categories of salaries, hourly, overtime, premium overtime, material, equipment/vehicles, refunds, and several combinations of these cost categories. Keep in mind this is for every individual project for each shop associated with the project! (Last fiscal year, that could have amounted up to 1,200,000 fields of information in this file alone!)

The work order transaction file can't survive of and by itself. It has to receive its data from a multitude of sources. These sources are other transaction files which contribute to the work order transaction file. The other transaction files are regularly emptied into (posted to) individual work order transactions still open in the work order transaction files. Let's examine these other transaction files next.

Transaction Files

Labor transaction file. As the name suggests, this file collects data representing labor charges. In order for this file to accept a transaction (time card) several conditions have to be met, including:

1. the employee's social security number must be on a non-terminated basis (Personnel Master file),

2. the work order number and card number to which the employee is trying to charge time must be active on the work order transaction file,

3. the shop-code on the employee's master record (in the Personnel Master file) and the one on the work order transaction must be the same,

4. the work order transaction must not be flagged for materials' charges only,

5. the labor transaction with the exact same date, work order, etc., can't already exist on the labor transaction file, and

6. some other peripheral edits.

The screen format which is used for entering labor data has several features in addition to the edits described before. These help us to audit the number of working hours of various types the employee is reporting.

Transactions are stored in the labor transaction file until we post them to the work order transaction file. There is no cost information stored in the labor transaction file; only hours are stored so that we could easier make adjustments without muddying up audit trails. In addition, it keeps employees' pay rates more secure. Pay rates exist only in the Personnel Master File and are never shown or printed anywhere else as part of a regular routine. (The Personnel Master File can only be accessed through a special password.)

Material transaction file. When material transactions are entered they have to pass the same basic edits as the labor transactions. If the project is closed, or was to be a labor only project, material charges can't be charged.

The screen requires us to provide an object code (based on our institution's general accounting system) for the transaction, a description of the item(s) purchased, the type of transaction (purchase order, inventory, etc.), the value of the transaction, and date.

As with the labor transaction file, the entered items stay in this file until they are successfully posted to the work order transaction file.

Equipment transaction file. Where a specific piece of equipment is being charged to a project, its equipment number must exist on the Equipment Table. The shop-code listed on that table must match an existing item on the work order transaction file and the shop-code on the equipment transaction being entered.

As the usage of the unit is being entered, it has to pass the same general edits as the other expense transactions. We only submit a number of hours which the unit has been used for the project identified. When the item is posted hours are translated to cost. However, the hours reported are added to an accumulator in the Equipment Table, which keeps track of the total number of hours each piece of equipment has been used since we started IRMA.

Posting of transactions. On a weekly basis, on Monday afternoons we post all the labor, material, and equipment transactions submitted through the quitting time Friday evening. Monday morning is used to clean up the stragglers after which transaction and edit listings are run to clean up any remaining error conditions. The transaction files are then locked, hours are translated into costs, and cost information is shuffled over to the work order transaction file.

Output from the transaction files. It must be pointed out that the most significant printed output is not necessarily the fixed format, preprogrammed, regularly scheduled material. Many, many times the rewards lie more in producing the quick-and-dirty reports. These usually want specific information pertaining to select portions of a file. Our operating system (Reality) allows easy generation of such reports by non-data-processing types. Our work order transaction file is designed the way it is to allow the compilation of many different varieties and combinations of data through this easy process. We can pull off data by building, and/or shop(s), and/or work types, in combination with each other and other factors.

We have a variety of fixed format reports. Interaction with auditors (internal, state, and federal) has convinced us that we need to retain sufficient detail to justify any expenditure. Furthermore, we need to keep that information around for a number of years and it must be understandable to individuals other than ourselves.

It would be easy to go into great detail in describing our output. Instead, the major output will be listed, each with a brief description of its nature and purpose.

1. *Transactions, edit, and posting listings* records the status of the various transactions from input through posting, providing the ever-necessary audit trails.

2. Journal entry listings summarizes journal entries which we generate in our general accounting system with our various transaction types.

3. Weekly summary (Custodial) summarizes by work type within each building, by building and by shop-code, the weekly and year-to-date activities (manhours, labor expense, other expense) of custodial crews, and compares them to allocated budget figures. Also, projects anticipated annual cost per ft.^{2} per building, shop-code, and the entire Custodial Division.

4. Budget status report summarizes for each shop its cost activities for the week just completed, the preceding week, and year-to-date making budget comparisions and projections. Summarizes information by general categories (salaries, hourly, overtime, supplies, refunds, etc.). Generated weekly.

5. Weekly activity log lists all currently active work orders by shop with an indication as to whether or not each job has ever been worked on and if so, how long ago. Generated weekly.

6. Billable reports list activity for each individual billable job for a defined period of time, separating data by shop. It lists all jobs for which any one shop has a non-closed work order giving current period data and costs, and year-to-date costs. (Shows only billable rates for employees, not their actual pay rates.) This report is run routinely on a weekly and monthly basis.

7. "Look-up" screen allows any interested party to look up a specific work order transaction in order to identify current costs, last activity date, and current status.

Preventive Maintenance System

The term "preventive" maintenance to our organization carries with it the connotation that what we're trying to "prevent" is (a) down-time on critical equipment and (b) unplanned replacement cost of significant equipment. We might add to that a third "prevent": we're trying to prevent our people from running around without some level of scheduled effort. In designing the P.M. program into IRMA, we tried to keep in mind those general objectives.

As a first step we established a table of action codes. These action codes tell the plumber, or electrician, or whomever what tasks they are expected to perform on the specified equipment, during the particular visit. These action codes are a permanent part of the scheduled services. They are in full English descriptive terms and are unique for each shop code.

The P.M. master file itself contains the real meat and potatoes of the program. Each record's "fixed" information includes items such as (1) card number and work order number, (2) equipment description, nomenclature, serial number, etc., (3) primarily responsible shop, (4) location (building, room, etc.), (5) warranty expiration date, (6) service frequency.

Also, in each master record are schedule indicators which show up on the screen, as an example:

```
          09/01          0123          3 hours
          10/01          0123          3 hours
          11/01          0124          3 hours, etc.
```

The date refers to the start of the period during which indicated work should be completed. The second column indicates the action code representing the work which is to be completed. (Notice that in designing the layout for this P.M. record, we allowed ourselves the option of indicating different action codes for different shcheduled dates. This has proven extremely helpful in handling seasonal needs.) The last column suggests an average number of working hours necessary to complete the indicated action code.

Every month we generate the service orders necessary to complete all the scheduled work for that month. In quantity, the amount of orders printed by IRMA varies from approximately 500 to 1,000 items. These are distributed to the appropriate shops sorted by building (to minimize unnecessary travel time by the worker.) As each order was being printed, the system checked the work order transaction file to make sure a correct, active item was present to start receiving charges (alerting the operator if there wasn't).

The printed service order shows information which may be necessary to locate the equipment, as well as the work order number and the card number which the employee will need to charge time and materials. The main body of the service order has a full English description of the action code to be completed. We opted not to print scheduled hours, even though that data is on the file.

As work is being performed and being reported relating to the P.M. card number, charges are posted to the P.M. master file as they are being charged to work order transaction file.

After some activity has occurred on a P.M. card number, the screen would show the same "fixed" information as a header, but the line items shown above could look like this:

```
     09/01     0123     3 hours     2.5 hours     17.00     8.50
     10/01     0123     3 hours     3.0 hours     21.00     2.80
     11/01     0124     2 hours
```

This information would indicate to the observer that September's service took 2.5 hours instead of the scheduled 3 hours, that the labor cost was $17, and that $8.50 worth of materials were used. It also indicates that November's service has not yet seen any action. Keep in mind that the P.M. master screen shows activity broken down by period of time (monthly) for any and all shops reporting any activity for that card number during that period of time. The work order transaction file will show year-to-date activity for each shop individually for that card number.

Occasionally, a service call may be required on a piece of equipment between scheduled services. When such an order is prepared using the P.M. card number for the piece of equipment, a line item will be created on the P.M. master file. It will be flagged as <u>subsequent</u> and will collect expenses reported to it before the next regular scheduled order is issued for that card number. Any and all subsequents issued to any shop will be included in this file, attached to the master record.

It must be emphasized that one aspect of our organization which helps make all of this successful is that all orders are issued out of one office: P.M., subsequent P.M., non-P.M. maintenance, etc. This helps control and review of the input into the work order transaction file and the P.M. master file.

Output from the P.M. system, aside from the screen described above, includes the service orders generated and a listing of the total P.M. master file by shop for review by various levels of management. Being developed at this time is a routine which will allow evaluation on a monthly basis of items scheduled and completed (or sometimes, not completed). The next step is to compare data in this file with data in our Capital Equipment Inventory file to determine replacement schedule, etc. Various one-time reports are also frequently generated.

Key Control Programs

No matter how you cut it, keys are a problem. Keeping track of who has what is an even bigger problem. We believe that IRMA has the ability to keep accurate records of keys issued to individuals within our institution.

Policy requires that only department heads (or one designee) can approve requests for keys. We have, therefore, generated a table listing all departments by name and number. One authorized signature is listed for each department. Since this table is stored in the computer, it can be accessed at any time and updated any time.

The key file itself is built around a hook number. This number stays with the same lock forever. Each hook number constitutes one record with its own set of information describing where the lock is (building, room) and what kind of lock (Grand-Master, Sub-Master, Room, Utility) it is. Attached to this are up to 500 issue numbers, which are also stamped into each key when cut. Each issue number, when assigned, has attached to it information identifying the individual holding that key. Included are (1) staff/student/faculty/other, (2) name, (3) social security number, (4) department number, (5) date of issue.

When the holder's information is being entered and the department number is keyed in, the screen accesses the department master table. On the screen will appear the department name and its only authorized signature. (If the information on the screen and the key request don't match, the latter is rejected.)

After having been entered and filed, the individual's name will be tagged with the hook number/issue number combination until information is received (along with the right key) that the individual no longer is authorized to possess the key. We are required by policy to perform regular audits of information on the file and departments are mandated to assist in review of the file.

We have designed output which facilitiates that challenge. We can, with the greatest of ease, pull off printouts (1) by one or more departments (or all), (2) by one or more social security numbers (or all), (3) by one or more building numbers (or all), (4) for an individual hook number.

We feel confident that as long as departments on campus help us by living with the policy, we will have an accurate information system. At least we have provided to departments, security, and auditors included, the means for enforcing the policies regarding key administration. We are planning to develop an interface between our files and the institution's employee and student files to help determine who no longer has need for keys. At that point, the entire information cycle is expected to be complete.

Motor Pool System

This system has been set up to accommodate control of campus vehicles and the expense to run and maintain them.

1. The Account Table consists of all departments with their appropriate account numbers.

2. The Vehicle Table is a complete catagorical listing of all vehicles and the specifics associated with each (i.e. lease plan, make, model, serial number, vehicle number, and license).

There are three input screens to accumulate cost. These screens work with the vehicle table and account table as an edit function to the system.

1. The Gas and Oil Screen has been set up to accept the charges per vehicle for gas and oil per visit. A monthly report is run for billing purposes. The report is a transaction listing by department and account, and by vehicle, plus cost at a billable rate table within the system. Also, from the input in this screen a vehicle report is run which compiles all transactions on that vehicle during the month.

2. The Service and Repair Screen is for all cost of maintenance on a specific vehicle (on the Motor Pool fleet only, i.e. yellow form). This form is used when any repairs are made or scheduled maintenance is done. The hours are put in and an automatic billing rate totals them. The cost of parts is entered and a sub-total for both is automatic. A monthly report is run for reference.

3. The Credit Card Screen is used to input charges toward the purchase of gas on leased vehicles (Motor Pool daily fleet) during travel away from campus or out of state. A printout is run to record verification.

At the end of a six month period, a total report is run accumulating costs of campus gas and oil, service and repair, and credit card purchases, plus the mileage on the Motor Pool fleet. This report aids in deciphering total cost of a given vehicle and in considering purchases of any new ones, plus aids in a more accurate view of usage and record keeping. We are expecting that we will be able to tighten the reigns considerably on the Motor Pool operations (a self-supporting organization). Coincidentally, we will have better audit trails on the operation of the organization and its effect on the many different sources and types of funding within our institution. We also hope to develop soon computerized R&R schedules for each fleet and for the entire Motor Pool operation. These schedules exist now but are maintained manually.

Capital Renewal and Replacement

A relatively minor computer program which as had a major impact on our overall success is called the Capital Renewal and Replacement program. The file is filled with data recently collected by our maintenance staff who did in-depth inspections of all facilities. The file will contain information indicating what individual projects need to be undertaken, which can't be funded by our annual maintenance budget, but which should be completed within a specified time in order to return the facility to a like-original condition. Data on the file regarding mechanical equipment will also include considerations of life expectancy, installation data, and replacement costs. The anticipated source of funding is identified as well for each line item.

As mentioned earlier, we expect to compare information contained in this file with data within the P.M. master file. We have, therefore, allowed room to indicate P.M. card numbers on this C.R.& R. file where they might pertain. We anticipate being able to generate reports which show on an exception basis those items or systems whose maintenance costs exceed a reasonable limit.

In the meantime, records within the C.R.& R. file will be used to generate data for our institution's administration by building, source of funding, year, and work catergories in any combination while summariaing estimated cost. Listings from this file will also be utilized to generate a back-log of "small" projects for each of the shops. There will be as many as 15,000 records in this file alone.

Custodial Standards Program

The next information system developed was the Custodial Standards Program. A manually maintained program has existed which has been of tremendous help to the custodial management team. It has helped make a couple of critical decisions:

1. What level of custodial staffing is required in brand new space, or existing space with a new function, and

2. how well is the existing staff doing in performing clearly assigned tasks (quality, cost, etc.).

Essentially every space in every building of our institution has an inventory form on file. Each form identifies for the space to which it pertains: (1) Kind of floor covering and square footage, (2) congestion, (3) number of light fixtures, etc., (4) the kind of space.

Each factor has attached to it a standard time requirement, or a weighting affecting total time requirement for the space. (These factors are re-evaluated constantly through time and motion studies.) After inventory forms for each area of the campus have been completed, custodial management compiles what's been proven to be a highly accurate guide indicating manpower needs for areas, buildings, and the institution as a whole.

We expect by computerizing this program we will be able to make the standards program more responsive to change. We will build a time factor table, identifying the standard time for precisely defined operation. We will also build an inventory file identifying the specific operations required in any space. There will be an estimated 13,000 inventory items on this file.

Using such an approach, we will be able to generate current needs for any defined space, or building, or group of buildings on demand. Custodial management itself will be totally responsible for keeping the time standards table absolutely current.

Utility Cost Analysis

With the continuing pressures of utility costs, we will soon develop a utility usage record keeping system for metered facilities. We anticipate devising billing schedules for facilities which must pay their own way. We expect to integrate some of the data with information generated by our highly successful JC/80 system, which today is totally monitoring most major structures on our campus. At such a time we expect to have a much better handle on total utility consumpiton patterns which in turn could encourage the administration to make some key decisions regarding space utilizations.

Draw-backs of Computerization

Living with IRMA isn't entirely a bed of roses either. Some traits which we intentionally designed into the system make life more difficult for many first line supervisors. It catches many of their "mistakes" which previously went largely unnoticed. Therefore, considerably more accuracy is required on everyone's part.

No new information processing system, whether manual or computerized, has ever been implemented without placing serious demands on management skills. This is true even if an earlier generation of a system had been used before the current implementation. If you are working with a group of individuals who are extremely comfortable with their ways and whose efforts are producing results within an established set of expectations, you could be comfortably advancing to the rear.

Computerizing will not of itself make projects flow more smoothly, costs to be more accurate, manpower to be utilized more efficiently, response to requests to be more timely, or any of those things. It is only a tool provided to management teams, who can use it if they choose. If any key group chooses not to utilize these resources (or worse yet, decides to boycott the information flow) you're dead! For such reasons, enthusiasm for the concept of computerization has to radiate downward freely and convincingly. And if your management team can't do that with consistent success, your stated objective may have a tough time being actualized.

Another consideration is cost. Buying the hardware is not necessarily the most expensive part of computerization (although it certainly isn't cheap). The cost in real dollars relating to development cost will appear staggering, usually in retospect. Unless a major investment can be made both in terms of time and dollars, the effort at computerization will fall far short of expectations. If you are too stingy when developing the system, you will pay double in maintenance and alterations later.

Finally, and concurrently, there's always the concern about higher levels of management. Aside from having to agree to a commitment of staff time and bucks, upper management has to be able to specify the results expected. Simply deciding that "it's time to get this stuff on a computer" doesn't suffice. Defining expectations and the degree of willingness to underwrite the means to accomplish those expectations is much more difficult. Doing that with some success will tax heavily upper management's ability to communicate with and to analyze the input of reactions from other levels of management. A commitment has to be expressed to support the implementation and maintenance of the system while it is being developed and after. A great amount of salesmanship is not only desirable--it's totally necessary.

Generally speaking, IRMA's our pal. It is able to talk to us intelligently, giving us answers with an accuracy which we have come to expect. It is flexible in response to our needs, yet it is tight in regard to edit functions. It helps us schedule, follow through, estimate, and evaluate. It is already helping us to prove to those "who must be obeyed" that we are better than they feared and proving to ourselves we're not as good as we had hoped. IRMA is an expensive baby, but it's a quiet one. We have to wait for the passage of time to see if it will result in better maintenance management along with its fringe benefits.

We are convinced it will!

Training--A Supervisory Sucess Story
A Way of Setting the Pace for Professionalism

Curtiss E. Crossley

I. Introduction

A brief description of the University of Illinois at Chicago and the variety of needs of the community is as follows:

The University of Illinois at Chicago is an urban "community" commuter university serving approximately 25,000 students. The Health Sciences Center was established in 1879 and the University Center was established in 1963. The campus is comprised of 32 buildings on 45 acres at the Health Sciences Center and 26 buildings on 118 acres at the University Center. The total building square footage for the Health Sciences Center is approximately 3.5 million square feet. The total building square footage for the University Center is approximately 4 million square feet. The enrollment figures for the previous school year are as follows:

The Health Sciences Center undergraduate division had 1,514 students.

Professional and post-professional students	2,578
graduate students	835
Total student enrollment	4,927
For the University Center, undergraduates total	16,993
The graduate students total	3,670

The operating budget for the University of Illinois. The Health Sciences Center, including services for crippled children, $271,359,618 and University Center $104,646,655. Those are the monies appropriated for the fiscal year ending 1983 for the University of Illinois at Chicago. The faculty and staff sizes are: the Health Sciences Center, 7,039, and University Center 2,672--both administrative, academic and nonacademic faculty and staff members. The information that I have given you does not contain the house staff at the Health Sciences Center.

The reporting unit for nonacademic staff at the University of Illinois is Facilities Management, with an Associate Vice Chancellor reporting to the Vice Chancellor for Administration Services.

Physical Plant is one of the major departments of Facilities Management. Within Physical Plant, Building Services is a part of operations. Building Services has the responsibility for interior cleaning of all buildings on campus, washing windows and restricted wall washing. Including the supervisory staff, the total number of employees is 200.

Building Services was selected as a training experiment because of the problems experienced over the past few years. During the period from 1975 to 1980 there was a rapid turnover within the upper levels of management. The rapid turnover of managers resulted in a large turnover of workers. Continuity was lost and high absenteeism, low morale, decrease in productivity prevailed throughout the unit.

II. Needs Assessment

The approach that we took in determining what specific needs we would address is as follows:

1. We looked at the equipment that was being used in Building Services;
2. We looked at the number of people employed in the department;
3. We looked at the number of buildings that Building Services had the responsibility for maintaining at an acceptable cleanliness level;
4. We looked at the quality of work; and
5. We looked at the standard of performance of Building Services' workers.

After we examined these items, we looked at what resources we had available. We found that because of budgetary constraints we did not have the amount of money that we would like to have had in order to have a profound effect on the equipment. We could not hire any additional people. We were under a hiring freeze. The number of buildings remained constant. So that left the quality of work. We are working with people and certainly we could have an impact upon people and the work they do. We examined the available research on management style and techniques of improving productivity. We examined the research on improving the quality of work. We further took a look at and began to analyze leadership styles that would encourage productivity and have a positive impact upon people. Since we have decided to improve the work quality, we looked at the leadership styles of management and supervisors in terms of identifying the style that would impact in the most positive way on the workers.

How did we do that? We examined our leaders by becoming a part of the crew and we will talk about that in a few moments.

III. Development of the Training Program

Most companies spend more time and money maintaining their buildings and equipment then they do developing people. We certainly did not want to fall into that trap. Since we had a limited amount of resources and money, we wanted to impact upon the workers through the mechanism of training. Some things that we had to consider in developing our training program were arrangement of training times and encouraging two-way communication.

One of the hassles that presented itself in the development of the training program was the three shifts involved in our operation. At the time, we had people working from 6:00 a.m to 2:30 p.m. and 3:00 p.m. to 11:00 p.m. The majority worked from 11:00 p.m. to 7:00 a.m. It was difficult to develop or identify a class time that would be convenient for the members of the three shifts.

What we did was identify two training times. Since the majority of the force was on the midnight shift, we established a training program during that time. We also planned and developed a combined training program for the day and evening forces. This would permit individuals from the day and evening shifts to alternate on making overtime. That was an incentive to get people involved in the training program. For the night force we decided that we would reward those attending training with one hour overtime on Fridays.

The schedule was something like this: Monday and Wednesday we would have members of the day force in class. Tuesday and Thursday we would have members of the night shift in classes and on Fridays we would have both groups come together at a time that would allow for an hour overtime for the night force. The evening and the day shift alternated on overtime between Mondays and Wednesdays and the night shift was given the opportunity of having one hour of overtime on Fridays.

Let's look for a moment at our managerial structure. We have an Associate Vice Chancellor; we have Physical Plant Directors; we have an Assistant to the Director of Physical Plant; we have a Superintendent of Operations, Assistant Superintendents, Building Services Supervisors, Building Service Foremen and the workers. In that managerial structure where should we begin training?

If we began the training with the worker and the managers were not in tune with what we are trying to do, we would have problems. We decided to plug into the managerial structure at the building service supervisory level.

After we looked at the training times and the worker schedule we had to encourage dialogue between the trainer and those people who the training was designed for.

A problem existed. The problem was that we brought in an outsider--myself--and it was a matter of acceptance. Our approach to resolving the problem was that I would spend adequate time on each of the shifts on an eight hour per day basis. This helped overcome the initial resistance of being accused of being a spy for management. It took some time, but by my constantly being with a group of supervisors and getting to know what they were doing and they in turn getting a better feel for me, I was accepted as a trainer and not as a spy for management.

In the development of the contents of the training program, it was based on the tenet that the experts are the supervisors. If I combined the total years of service of the supervisors it would amount to 80 years. My philsophy was "Listen, you know better than I what you do. You've been doing it for a number of years, but you may not be doing it correctly but you have been successful at doing it. I have some ideas on how you can improve. Let's talk about what you see as the problem. How do you think we can overcome those problems?"

I would listen to the supervisors and after listening to the supervisors I would go to one level above the supervisors and listen to that level in terms of what they see as the problem or problems in the supervisory level. I would then proceed down to one level below the supervisors--the foremen--and listen to and encourage the foremen to share with me their ideas on identifying problems and issues.

It worked out very well. We developed a six-month training program by incorporating ideas from the supervisors and their managers and by incorporating some ideas and thoughts of my own that I believed would enhance the standards for the trainees.

We had such a success with our supervisory training program that we decided to go one step lower and develop a training program for the foremen. We based it on contents that we had developed for our supervisory training program, but we made some changes that were more appropriate for foremen. We then went one step further and developed a training program for building service workers. We used the slogan "Learn By Doing," but we also had a formal classroom setting and I was fortunate enough to be provided with a training room.

IV. Results

The results of our training program are vividly highlighted by a survey developed by the Vice Chancellor for Administration Services. This survey included all the nonacademic units that provided services to the academic staff and faculty, including the accounting division, general stores, duplicating services, organization development, University Police, mail services, bookstore, food services, parking office, recreation office, utilities and personnel and others. I might add this is the first time such a survey has been used.

This survey had a score of four as the highest possible rating a unit could receive from a user of services. Building services or housekeeping in 1981 had a rating score of 1.94. After we began our training program, the survey was conducted one year later and we had moved from a rating of 1.94 to a rating of 2.52. We certainly don't attribute the move entirely to just the training program, but we believe that our training program certainly had a impact upon our delivery of services.

We know that our discipline problems are fewer. We are not without discipline problems, but we see that the number of discipline problems have been greatly reduced. We had a large turnover in our work force--that has decreased considerably. Many of the users of our services have complimented us on our professional attitude. We have received numerous letters of appreciation for jobs well done. People are talking to each other on the work force. There is a friendliness throughout the the Building Services workforce that you would not believe.

Increased visibility on campus has also had a positive impact upon our unit, but we can't take credit for that, for during the training program, the majority of the workforce was shifted from the midnight shift to days.

What guided us in the training program was the principal of leading by example. We said, "Listen, we want a more professional performance out of you and we want a better quality of work out of you." We accomplished that by doing better work ourselves. We set the pace for professionalism by doing what we expected our followers to do.

I appreciate the opportunity of sharing these thoughts with you. Just to highlight what we have said, in our supervisory success story, we used training as a vehicle; we developed the training program around communication; we allowed the individuals that would be participants in the training program to identify the training needs. We allowed the individuals to be trained on their work site, rather than taking them away from their work site and placing them in an artifical environment. We based our training program on what people listen for and whom people listen to. The last thing that we did was follow the tenet that you "learn by doing."

AN EFFECTIVE INSTITUTIONAL ENERGY STRATEGY

By John R. Swistock
University of Virginia

We have, in some respects, come full cycle in ten years since the 1973 oil embargo. From gasoline shortages, the demand for smaller cars and the frantic search for alternate fuels, we have come to gas wars, a strong demand for performance cars and cancellation or reduction of many energy projects. To assure that we don't lose the true perpective of the energy situation, let us recall some pertinent facts; in 1973 crude oil costs were about two dollars a barrel, today the OPEC price is twenty-nine dollars a barrel, in 1973 a KWH of electricity cost the University of Virginia one cent, today that cost is about five cents, and in 1973 natural gas was about fifty-five cents per 1000 cubic feet , today natural gas is almost ten times that. While the rapid cost increases in energy has apparently subsided, the costs are in fact very high by historical standards.

We have apparently reached an energy plateau, a plateau that has basic energy costs five to ten times that of what it was ten years ago. While energy costs are high, they are more predictable than they were ten years ago. Our energy supplies seem more assured. Therefore, the crisis environment that existed ten years ago does not exist today. While most basic energy costs have risen two to five times faster than inflation in the past ten years, we probably won't see that rapid increase in the near future, barring an upset in the fragile stability of the Middle East or Mexico or other major energy producing countries. However, it is extremely doubtful that we will, in the near future, see energy costs increase at rates below that of general inflation. Energy will continue to demand a much larger share of our resources than it did a decade ago. After salaries therefore, energy will probably continue to be the biggest operating expense of most institutions for years to come.

The task of improving our institutions energy effectiveness will undoubtly be more difficult in the next ten year than it was over the past ten years. In addition to the situation I have described, the easy, quick pay back energy conservation initiatives have, at many colleges and universities, been completed. Caulking and weatherstripping, installing time clocks, disconnecting unneeded lights and similar low cost energy conservation measures should have been completed at all institutions. Installing computer based energy management systems, variable level lighting controls and waste heat recovery systems, converting constant air volume air conditioning systems to variable volume and replacing or converting existing equipment to use lower cost fuels and alternative energy sources are all generally capital intensive requirements that will compete for funding with other capital programs.

Therefore, given the probability of more predictable supplies of energy in the near term and the capital intensive nature of future energy efforts, such efforts will have to compete with more traditional investments for available funds. The job of the energy manager will require more sophistication and more coordination with institutional managers and financial decision makers. This is the background against which a comprehensive energy strategy must be developed.

An effective strategy will obviously vary from institution to institution. But, given the common energy situation I have just described, the common goals of the strategy are, quite simply, to assure that current and future energy requirements for the institution are meet in a dependable cost effective manner. The elements of an effective energy strategy are ;(1) the strategy must support the institution's goals and objectives.(2) it should identify specific energy objectives, (3) it must be cost effective, (4) it must be supported by a comprehensive and sound engineering plan, (5) it should contain an education plan, (6) it must provide for increased energy reliability and (7) it must have an effective reporting, auditing, and feed back system.

Support of institutional goals. An effective energy strategy must clearly show direct support of the institution's goals. Generally, institutions of higher learning have three broad common goals, the first of which is to educate the citizenry, the second is to advance research, and the third is to provide community services. Colleges and universities do not exist to save, conserve or manage energy. Therefore the strategy must show that it will make the institution's objectives easier to obtain by assuring dependable, cost effective energy. The strategy should also provide an energy awareness model for students and the community. For instance, when a college administrator understands that a good energy strategy can save enough operating funds annually to support two more research assistants or purchase several hundred additional library volumes, he is much more likely to support such actions as implementing space temperature standards or shutting down air conditioning systems on the weekend. A metropolitan university demonstrating how major buildings can perform all their functions while using thirty percent less energy could be considered to be performing a valuable community service.

Specific energy goals and objectives. To credibly show support for institutional goals and objectives, the strategy must contain specific energy goals. These goals must be achievable, measurable and consistent with the total energy strategy and general institutional goal. It is not unreasonable to expect buildings built in the 1960's and before to ultimately show thirty to fifty precent reductions in energy consumption from their historical peak usage. With the more fuel efficient vehicles available, it is not unreasonable to expect automobile and mobile equipment fleets to show a fifty percent decrease in fuel usage from 1975 to 1985 while performing the same functions. Specific energy goals must accomodate institutional objectives. For example, if an institution is committed to significantly expanding its research facilities, extraordinary efforts may be required merely to maintain electrical energy usage at current levels. In this case a legitimate goal would be to have a zero growth in electrical energy consumption.

Generally meter readings or fuel usage records are the best readily available source of information for measuring energy savings, and goals should be established that can use such information to measure progress. Because of different electrical rate structures based on demand and time of day, as well as electricity usage, electrical meter readings must be carefully evaluated when establishing a goal for electrical energy use. Goals should be established to level electricity usage over time where demand charges are significant. Similarly, an objective might be to reduce electricity usage during those times of the day when rates are highest if a time of day billing structure is used by the local utility. However, as the goals should be easily definable and monitored, it may be better to establish an electricity usage goal based upon kilowatt hours consumed per square foot and another goal of dollars spent for electricity per square foot. This latter goal should be reestablished perodically or when unit cost change from that predicted. Such a gauge of energy consumption and cost per square foot has the advantage of being easily understood by everyone and progress against it can be easily measured. Where alternate heating fuels are available for discretionary use, heating cost per square foot goals would also be applicable.

The energy usage objectives developed by the University of Virginia are examples of such goals. These goals are detailed in Attachment One.

Cost effectiveness. The cost effectiveness of the total strategy must be clearly demonstrated if it is to receive the needed institutional support for success. Figure One shows the projected cost savings which can be expected to result from the adoption of the energy goals outlined for the University of Virginia. Figures Two and Three show the projected cost savings in electrical and primary heating energy which can be expected to result from the operational changes and capital investments projects which support the energy policy and strategy.

As individual elements of the overall energy strategy are developed, it is important to understand and communicate to the institutional community the projected cost savings to be realized. It is equally important to assess how such elements will impact on other aspects of institutional activities. The most easily accepted changes are those which either enhance community life or have no visible effect on it. However, such changes are the exception rather than the rule. It may prove to be the case that a proposed change is cost effective from an energy standpoint but would, in fact, cost the institution more than it saves when examined from a more global viewpoint. For instance, setting standards for maximum space temperatures during the heating season and minimum space temperatures when mechanical cooling is required is a basic element of any energy conservation strategy which must have support at all levels of the institution. Such standards are far more likely to be accepted if provisions are made for such areas as research spaces and libraries where strict adherence to a single standard could be counterproductive, and in conflict with institutional goals.

Energy conservation related capital projects are generally justified on the basis of time required to pay back the investment. However, by not indicating long term savings, such a justification does not fully show the true benefit of these investments to the institution. Again, the true cost effectiveness of any project must be judged by its total financial impact. The energy manager should consider all life cycle costs and savings in the evaluation of any project.

A good energy strategy will also impact on capital projects which are entered into for reasons other than energy cost savings. Building construction and renovation projects are excellent opportunities to improve energy efficiency. Strict but realistic standards for energy efficiency in all construction should be an element of any energy strategy.

A sound engineering plan. A sound engineering plan is critical to the strategy if the institution is to achieve the desired and predicted results. The engineering plan should start with a multi-year energy or utility master plan. The master plan must address future institutional expansion or retrenchment goals. It must answer such questions as; is central or local building heating and cooling systems the most cost effective system for the campus, and should the institution have a single meter point for the purchase of electricity and distribute power over a campus distribution system or should each building be served by the utility company? These and similiar concerns must be considered in the utility or energy master plan.

If a campus has a major thermal energy demand in one location, cogeneration may be cost effective for the institution. The recent Supreme Court ruling concerning cogeneration could significantly influence this consideration. A knowledgeable engineering consultant should be retained to address such questions and develop the plan.

A second part of the engineering plan involves an ongoing program of energy audits at various technical levels for each building or complex within the institution. Walk through audits need to be conducted on a continual basis to insure that previously identified energy problems have not reoccurred. More detailed and technical audits should be conducted in each building on a schedule dictated by changes in building usage and energy technology. On a large campus, a reasonable schedule might call for a walk-through type audit of each building on a five year cycle and more technical audits conducted at intervals ranging from every ten years for complex buildings such as hospitals and laboratories to twenty or thirty year cycles for simpler buildings with more stable operations. The details of such a schedule and a determination of whether it will be done by the institution's staff or by outside consultant will vary with the situation. The important thing to realize is that such a program is a continuing one. Energy audits and updates of master plans need to be thought of not as one time expenses, but rather as an every day (or at least every decade) part of operating institution in the same way that fire and safety inspections are.

The utilities or energy master plan and the technical energy audit will indicate the direction any long term coordinated capital investment program should take. Energy related projects with a good return on investment may not enjoy widespread support within the institution. For instance it may be desirable from a cost standpoint to convert a central heating plant from oil or gas to coal and perhaps add cogeneration. Such an undertaking would be capital intensive and would also require a significant investment in personnel training and retraining: a major commitment of institutional resources. However, such a capital investment does very little to directly support the University objectives of education, research and community services. Capital investment in class rooms and research facilites obviously contribute more directly to institutional goals and will generally have more institutional support. With a creditable energy strategy, a good master plan and well documented return on investments, such projects can compete successfully with others for capital investment resources.

The engineering plan must also consider maintenance and repair programs such as pipe insulation and steam trap maintenance. For instance, it is not uncommon for a single steam trap to waste a thousand dollars worth of steam a month. Failed insulation on steam lines can be very costly. If maintenance of these items have been allowed to deteoriate over a period of time, replacement may be costly and beyond the maintenance budget. The engineering plan must provide some means to identify, quantify and cost out these items so that they can be addressed. This aspect of the engineering plan combines aspects of the institution's preventative maintenance and inspection programs with its overall energy strategy.

All energy systems must be addressed including inside and outside lighting, building heating, ventilating and air conditioning systems and building envelope integrity. Successful development of this portion of the engineering plan will enable the energy manager to show what must be done to maintain existing levels of energy effectiveness, what it will cost and what the long term dollar savings are.

The education plan. As wide acceptance and support of the energy strategy is essential for a high level of success, a good education plan must become part of the strategy.

When building occupants do not agree with mandated space temperatures that have been developed they simply will set thermostats higher. When thermostats are made tamper resistant, they will use electric heaters or wrap thermostats in a wet towel or think of some other way to raise the space temperature to the level that they feel is proper. The education plan is aimed at convincing everyone on campus that it is in the institution's and their best interest to save energy by complying with space temperature standards and all other energy goals and procedures developed. In many respects this is the hardest part of the strategy since it will require Physical Plant administrators or others responsibile for the energy strategy to enter the field of public relations, mass communications and education.

The education plan should include periodic energy related articles in campus publications and may include such undertakings as posting energy related signs on bulletin boards and installing stickers on light switches. This latter effort can be counter productive if posters and stickers are allowed to become "old". These items must be periodically changed and updated as they may contribute to the subliminal perception that energy management problems belong to the 1970's and are no longer relevant.

The education plan could include a session on campus energy management policies and goals as part of new student and faculty orientation. Such sessions provide an excellent means of reaching individuals when they are relatively open minded on the issue since they are new to the campus and probably anxious to support established policies. In later months the same individuals are much more likely to accept space temperatures that are part of the policy than they would if they were exposed to heating temperature standards for the first time on a cold October morning when the temperature in their dormitories and classrooms is sixty-eight degrees.

Another important part of the education plan concerns timely briefings of faculty and staff. Early each spring for instance, deans, department heads and chairmen should be reminded of the energy plan and how it will affect buildings during the upcoming cooling season. Such reminders can occur at staff meetings, in memorandums or whatever medium is proper for the institution. These communications however, should be specifically targeted to the intended recipient. An article in the student newspaper is probably not an appropriate way to remind a dean of such matters. The same sort of periodic formal communications are necessary with the governing board of the institution and its president or provost and executive staff.

These briefings and periodic articles in campus publications should also include results of the strategies to date. The amount of money saved to date and the energy conserved per square foot this year may be compared with the same period last year or some base period previously decided upon. This type of information should be disseminated monthly or quarterly.

The education plan then is a specific plan intended to obtain wide institutional support of the energy strategy and its related plans. A good educational plan will improve the creditability of the strategy as well as its effectiveness.

Increased energy reliability. Institutions of higher learning tend to be perpetual and non-migratory. Colleges and universities do not cease operations or relocate to a different state with the same ease that the manufacturing industries do. The energy strategy therefore, must address long term as well as near term energy availability and reliability. In this regard, long term could be considerably longer than ten years.

While energy sources and supplies are currently adaquate and dependable, such was not the case only a short time ago and could easily change again. Current projections are that, as the industrial world recovers from the current recessionary period, demand for energy will turn sharply upward and the apparent current surplus of crude oil and natural gas could disappear in a short time. If a major political disruption caused a significant reduction in flow of crude oil in Persian Gulf at that time, oil shortages could quickly develop. With the North Sea, Alaskan and Mexican oil fields now exporting significant quantities of oil, the Persian Gulf is not as critical as it was a few years ago; however, the continued availability of oil from that region for the next decade or more is necessary for a stable energy situation in the free world.

Natural gas supplies currently appear to be adequate; however, prices are much higher than they were only two years ago, and the effect of deregulation on long term prices and supply is still a matter of speculation.

It is obvious then, that while the current energy situation appears stable and relatively predictable, this condition will likely change, perhaps several times, over the next ten years. The effective energy strategy must address this situation as well as regional and local energy availability.

The strategy must address each energy source. The utilities or energy master plan discussed earlier should address sources and costs of future energy. The possibility of converting to alternate fuels such as coal or biomass, and the possible use of solar or geothermal energy must be carefully reviewed. Cogeneration should also be considered and may prove to be a very cost effective addition to existing systems where heat energy demands exist on a year-round basis or where electrical power demand charges are significant. Such conversions are usually capital intensive and involve considerations such as fuel transportation and handling as well as potential pollution problems. In many cases, such conversions would require several years to plan, design and construct. Also, operation of these systems may require a significant training effort and establishment of different operating procedures before such systems become primary energy producers.

While major capital investments are required for cogeneration or conversion to coal, other avenues of increasing dependability of future energy supplies should be considered. Increasing normal storage capacity of fuel to a six month or more supply would not only provide some security against short term delivery reductions, but in times of adequate supply may allow for the purchasing of fuel at a discount by buying in the off season or when suppliers may want to move the product.

Obviously, methods to increase the future energy security of each institution will vary greatly, but in all cases it must be addressed by the effective energy strategy.

Reporting, auditing and feed back. To have a creditable strategy and an effective education system, a reporting, auditing, and feed back system is essential. All levels of management must be able to accurately monitor energy use and costs and energy users should frequently receive feedback on progress toward goals, or the goals will become just another institutional casualty and a major portion of the strategy will likely collapse.

Heating energy usage based on fuel consumption and normalized to square feet of buildings is an indicator that can be easily calculated and compared to established goals. In some circumstances, it may be desirable to factor in weather variations by using the readily available degree day information. However, as heating requirements are effected by wind, cloud cover and other heat sources in the building, the effect of degree days on energy consumption is very variable. In most cases, it is better to include a discussion of weather and other factors when consumption data is published or presented and limit data presented to energy used. Electrical energy use can be presented on a kilowatt per square foot basis. In most cases demand, time of day charges and similiar rates are best presented in the discussion of energy consumption and costs.

It is important that the indicator used to measure progress against goals be relatively simple, easily understood and quickly calculated, and that it be comparable to a specific reference base and to future goals. Using energy per square foot of building and gallons of fuel per mile for transportation equipment will generally meet these requirements for most colleges and universities.

These indicators should be computed and published monthly and could be used in appropriate meetings to inform all interested individuals of the progress toward the goals. It is important that everyone perceive the energy strategy as a dynamic ongoing process involving many individuals.

In addition to showing energy usage per square foot, it may also be advantageous to show unit costs of energy. Such a display is particularly useful to managers when more than one fuel is available for heat generation. For example, where a choice between oil or natural gas can be made such a display will quickly show the cost effectiveness of the fuel selection. With purchased electrical energy, such a display provides a good indicator of how well peak demand or time of day usage is being managed. Figures Four and Five show how energy costs as well as energy consumption can be periodically presented.

In addition to progress against usage goals, a project status reporting system should be developed. Most institutions have in place procedures for tracking construction projects. The same tracking system can usually be used for energy projects. Periodically however, the energy projects must be evaluated to assure that they remain consistent with the total energy strategy.

An effective feed back system must provide an easy way for anyone concerned to make input regarding any energy matter. Establishing and publishing an energy phone number is an effective method of accomplishing this. Additionally, some one individual should become well known as the energy expert, coordinator or manager, and personal contact to that individual should be encouraged. This can give everyone on campus the opportunity to become involved in energy management and will generally increase awareness and support of the total strategy.

Summary. Energy will continue to demand a major portion of colleges and universities funds. Energy is a resource that requires good management to assure its continued availability and cost effectiveness. Everyone on campus must be aware of and involved in the energy strategy if it is to be effective. The task of the energy manager has become more difficult as the public's perception of energy problems has faded. However, the need for effective long term energy strategies and management has never been greater.

The effective institutional energy strategy will support the institution's goals, contain specific energy objectives and be cost effective. It will be supported by a sound engineering plan and an education plan and it will provide for increased energy reliability. Finally, the effective strategy will contain a useful reporting, auditing and feed back system.

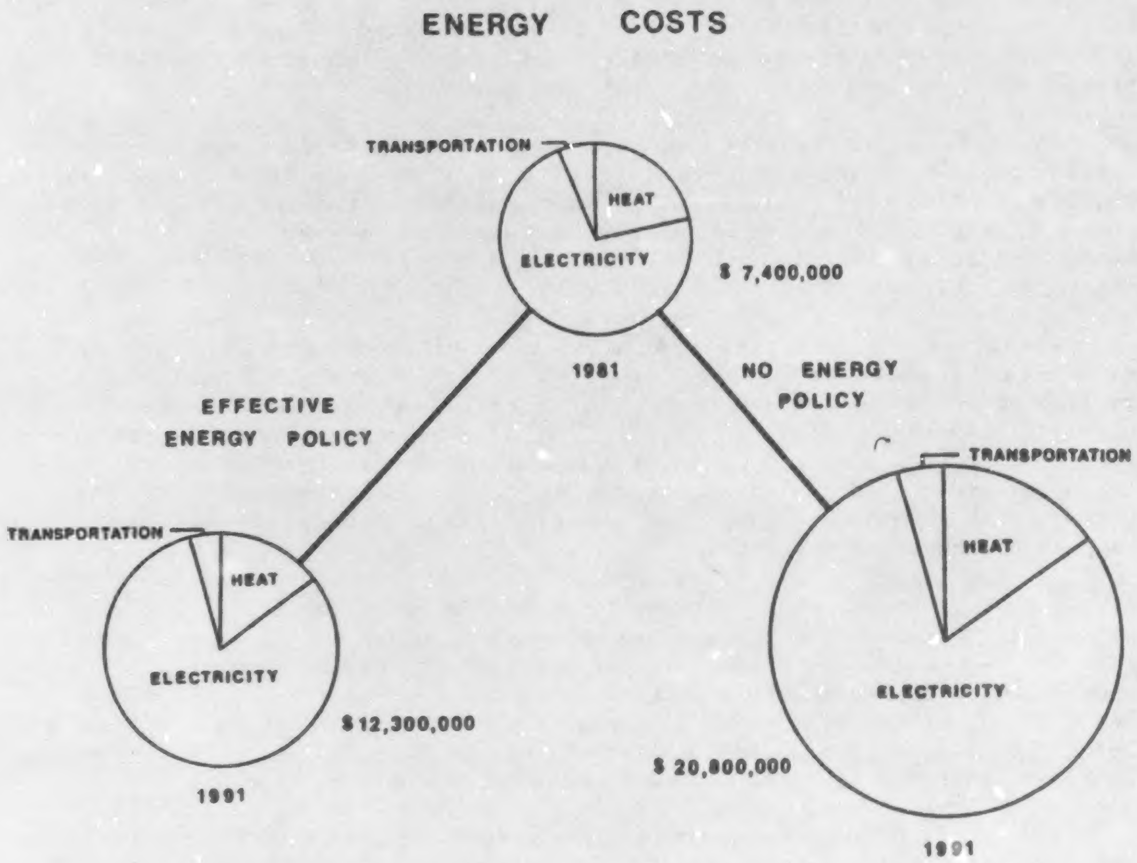

ENERGY COSTS
TRANSPORTATION
HEAT
ELECTRICITY
$ 7,400,000
1981
EFFECTIVE ENERGY POLICY
NO ENERGY POLICY
TRANSPORTATION
HEAT
ELECTRICITY
$12,300,000
1991
TRANSPORTATION
HEAT
ELECTRICITY
$ 20,800,000
1991

Figure 1

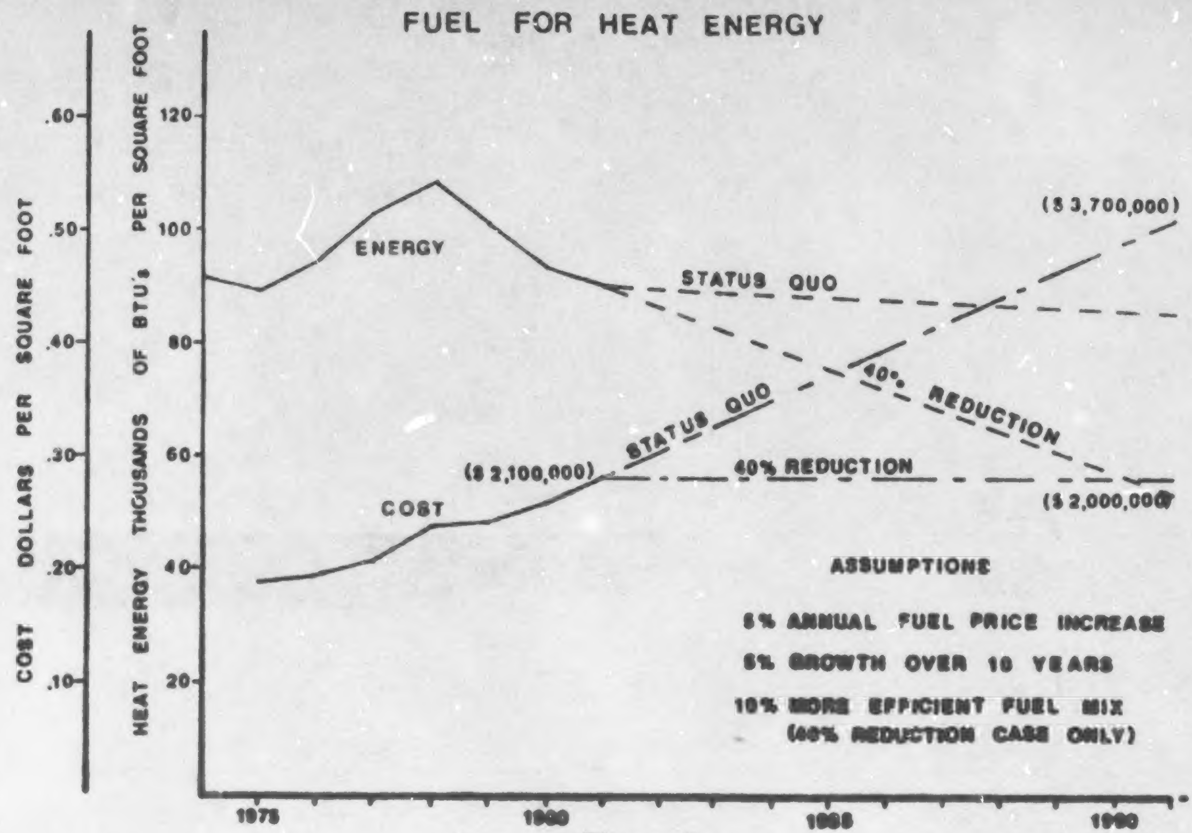


Figure 2

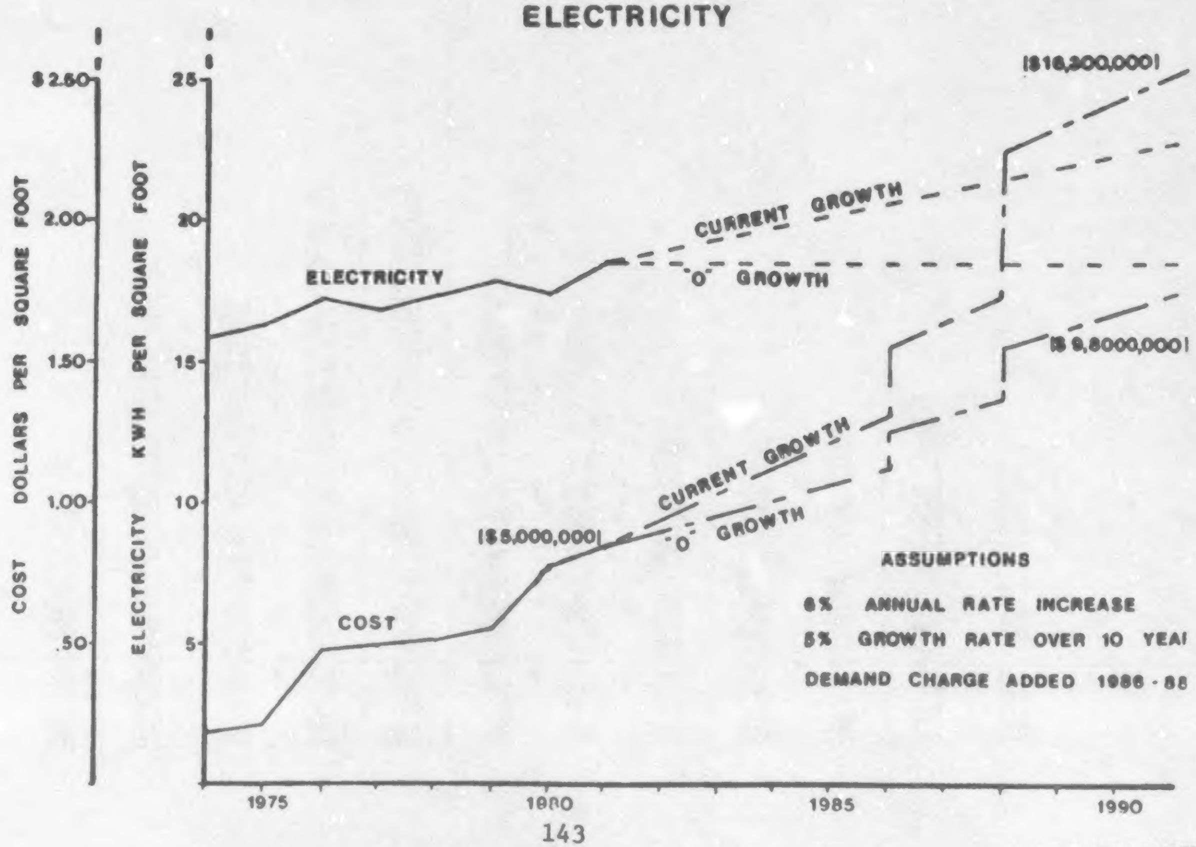


Figure 3

BEST COPY AVAILABLE

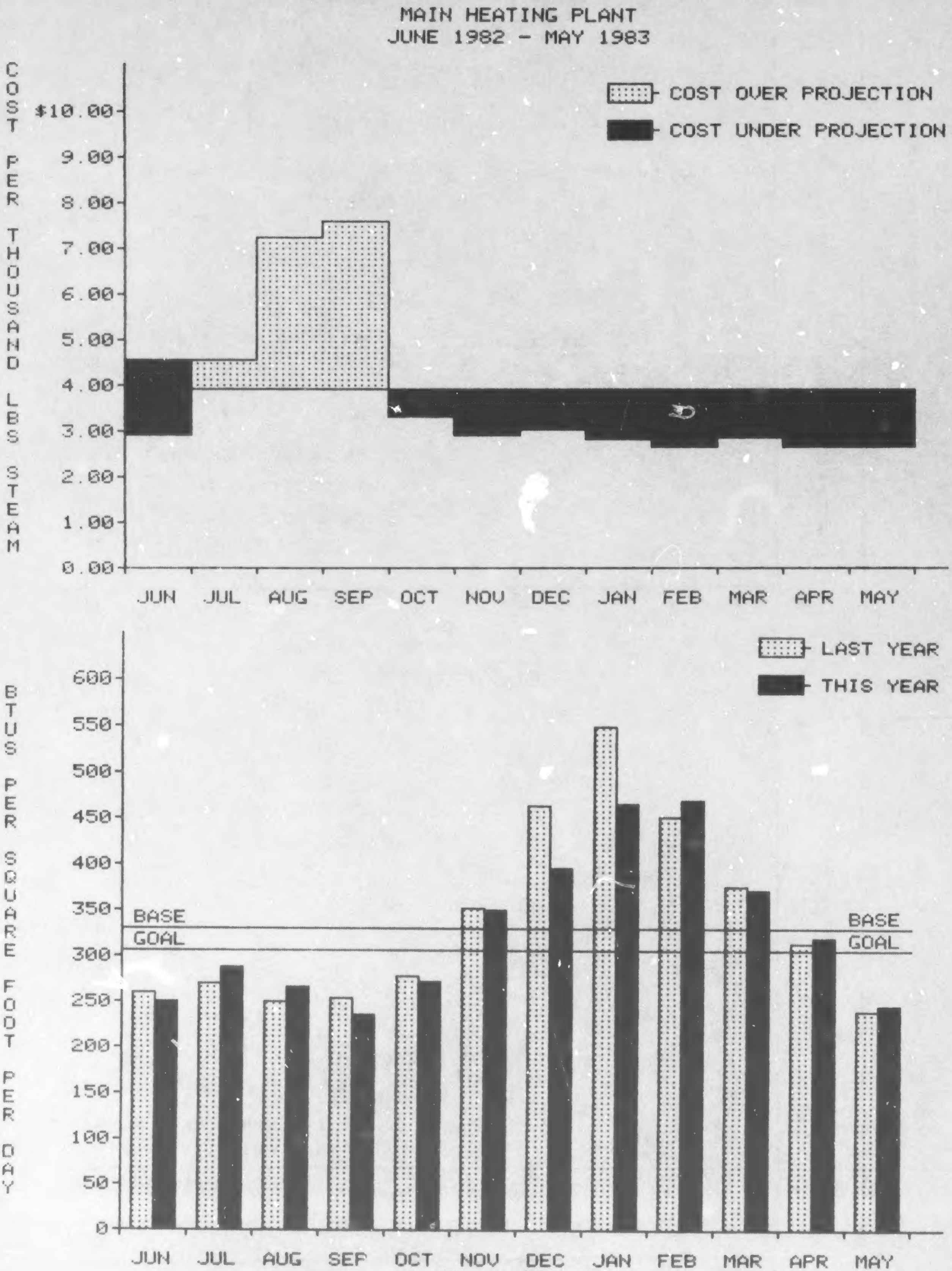

MAIN HEATING PLANT
JUNE 1982 - MAY 1983
COST PER THOUSAND LBS STEAM
$10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
COST OVER PROJECTION
COST UNDER PROJECTION
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
BTUS PER SQUARE FOOT PER DAY
600
550
500
450
400
350
300
250
200
150
100
50
0
LAST YEAR
THIS YEAR
BASE
GOAL
BASE
GOAL
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY

Figure 4

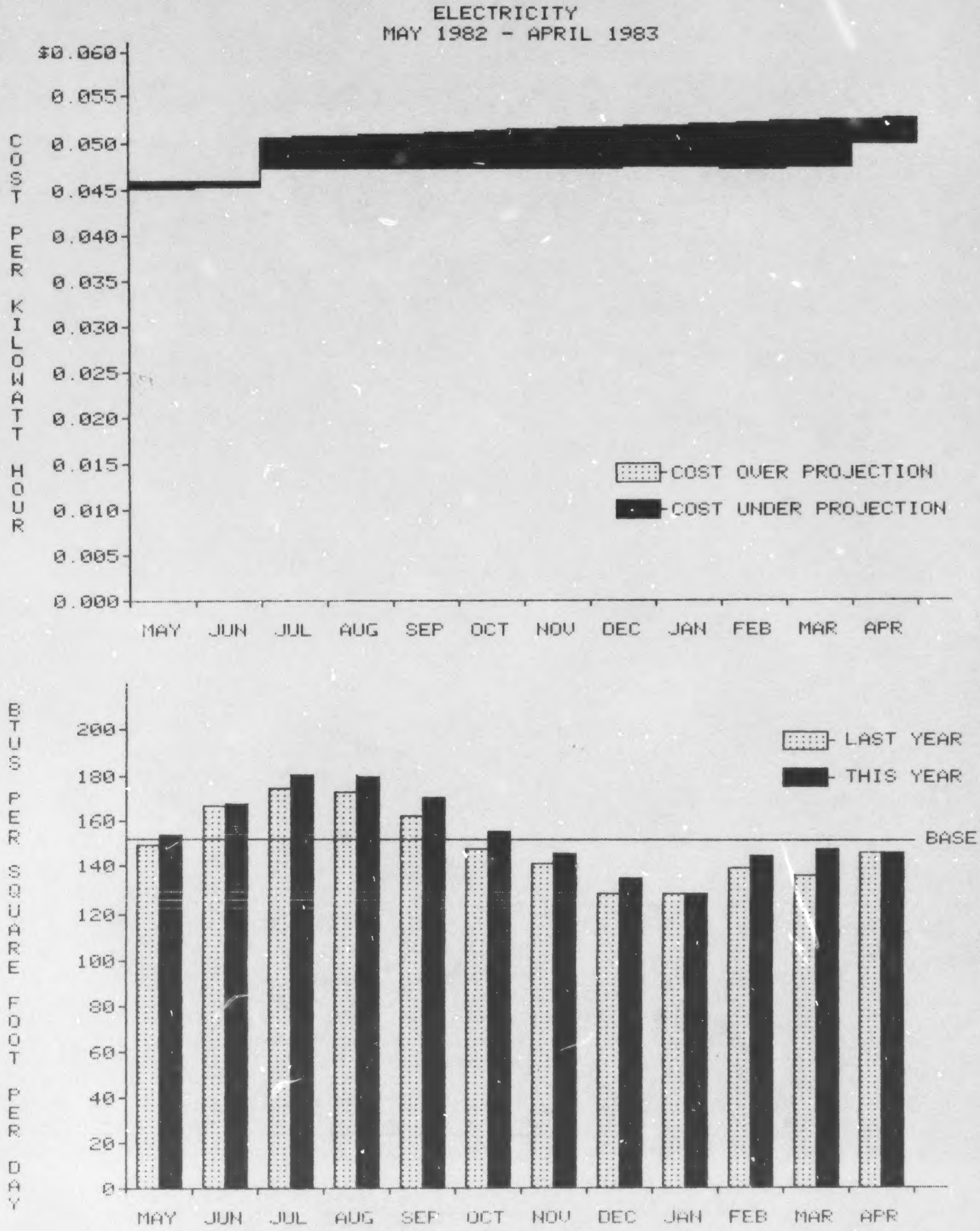

ELECTRICITY
MAY 1982 - APRIL 1983
COST PER KILOWATT HOUR
$0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
▨ COST OVER PROJECTION
■ COST UNDER PROJECTION
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
BTUS PER SQUARE FOOT PER DAY
200
180
160
140
120
100
80
60
40
20
0
▨ LAST YEAR
■ THIS YEAR
BASE
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR

Figure 5

Ten Year Energy Objectives
University of Virginia
1982-91

Objectives

It is a goal the University of Virginia to use all forms of energy in the most effective manner possible, therefore the following long range energy objectives are established.

1. Reduce heating energy consumption by 40% between June 30, 1981 and June 30, 1991 on a per square foot basis.
2. Realize zero growth in electrical energy consumption.
3. Reduce transportation energy requirements by 30% between June 30, 1981 and June 30, 1991 on a miles per gallon basis.

Introduction

In 1980-81 the University spent $2.1 million on fuel for heating energy, $4.9 million for electrical energy and $400,000 for transportation energy. Continued use of energy at the current rate over the next 10 years will result in a 180% increase in annual spending measured in constant dollars. This increase represents $13.4 million.

Through systems improvements, increased awareness and more effective management action this University expects between 1981 and 1991 to reduce heating energy by 40% measured on per square foot basis of heated University buildings. Further, electrical energy is expected to be used more effectively so that increased use of air conditioning, and all electrical equipment will result in zero net growth in electrical energy used measured on a per square foot basis of occupied University buildings. Transportation fuel requirements are expected to decrease as older vehicles are replaced with more fuel efficient models and actions such as better tune-up and more efficient use of equipment are taken. Over the ten year period transportation fuel usage should decline by 30%.

The Energy Conservation Committee will develop and recommend administrative policies and actions to further the realization of these goals. The Department of Physical Plant will incorporate energy effective concepts into new construction and renovations of University spaces, and will develop capital projects where appropriate to support these objectives. All administrators, staff and faculty should support actions that are in consonance with these objectives.

Attachment 1

Currently it is estimated that over the 10 year period, the composite cost of energy will increase faster than the annual inflation rate. This increase will significantly exceed the annual inflation rate when industrial activity increases in this and other industralized nations or unstable conditions exist in major energy exporting countries. The cost of natural gas over the next three years will increase significantly faster than inflation and pertroleum based fuel costs will over the next two years increase slower than inflation. Coal and electrical costs are expected to increase at a rate moderately more than inflation.

Energy reductions will require the expenditure of local and capital investment funds. It is estimated that $25 to $30 million will be required over the next ten years if the objectives are to be realized. These investments are expected to have an average three to four year payback. Many of the expenditures will take the form of increased costs of capital building projects to make them more energy efficient. Many of these costs will be in the form of capital projects to improve utility systems, i.e. power plant and electrical distribution systems upgrades.

ENERGY COSTS
(Dollars)

		1991	
	1981	With Effective Energy Policy	With No Energy Policy
Heat	$2,100,000	$2,000,000	$3,700,000
Electricity	$4,900,000	$9,800,000	$16,300,000
Transportation	$400,000	$500,000	$800,000
Total	$7,400,000	$12,300,000	$20,800,000

Attachment 1

Heat Energy Systems

Ninety five (95%) percent of the heating energy used by the University and Medical Center is produced by the two central heating plants. From 1981 thru 1984, in-house engineering efforts aimed at improving the efficiency of producing and delivering this heat energy will reduce consumption by five to eight percent. These efforts will be aimed primarily at improving boiler control, recovering additional heat from heating plant systems and reducing heat losses in process and distribution systems.

The use of non-fossil fuel heat energy will result in a reduction of requirements for fossil fuel heat. The use of University generated trash as a fuel source and the installation of active solar collectors will provide a six to nine percent reduction of fuel costs. Installation of such systems will require the committment of capital funds. Conversion to less costly fuels both in the main heating plants and in buildings served by their own heating systems will result in fuel cost savings of four to eight percent.

Developing dual fuel capability in buildings heated by distillate oil, and natural or LP gas will effect buildings on the perimeter of the University. Modifications or replacement of existing boilers to meet air pollution requirements will allow an increase in the precentage of coal burned in the Main Plant. The connection of buildings which currently have electric resistance or oil heating systems to the Main Heating will be accomplished where such connection is cost effective.

Modifications to heating systems in existing buildings and energy efficient design in new construction will reduce heating requirements by eighteen to twenty-two percent. Upgraded insulation, the use of passive solar energy, improved control of heating and ventilation system operations, improved efficiency or elimination of equipment requiring heat energy, and waste heat recovery will be incorporated into both new and existing buildings. These actions will require a combination of local funding and capital outlay support.

In addition to the above stated actions is it anticipated that increased electrical consumption for expanded use of electronic equipment will produce enough waste heat to reduce heat energy consumption to five percent. An increase in demands on heat energy systems will occur in areas where electric resistance heat is eliminated. The increase in heat energy usage of 1.5% will be very cost effective as electric resistance heat energy costs approximately 150% more than steam energy.

Electrical Energy

All electric power used by the University and Medical Center is purchased from VEPCO. Seventy percent of this power is delivered via the University owned electrical distribution system. It is anticipated that during the next ten years, the contract between the Commonwealth and VEPCO will be changed to resemble the present VEPCO industrial service contracts. This will mean that a demand charge will be assessed on peak power requirements in addition to the present electric energy rate. In anticipation of this action, the University will actively expand and upgrade the distribution system to provide more flexible management of peak electric demands. Based on the experiences of other users already on a demand type rate schedule, failure to consolidate power supply and distribution will result in a twenty-five percent increase in the cost of electricity.

Improvements in the efficiency and control flexibility of air conditioning systems in new and existing buildings will result in electrical energy reductions of twelve and fifteen percent. Additional improvements in efficiency and controls of lighting systems will reduce electrical consumption by two to three percent. Conversion from electric resistance heat to heat pumps and replacement of electric resistance heat with steam or hot water systems sources will save one and two percent respectively. Such modifications and improvements to existing buildings will require a combination of local and capital outlay funds.

However, requirements for improved environmental control of special use spaces will increase electrical requirements by eight to ten percent. In addition, it is anticipated that the increase use of electronic equipment will outstrip improvements in efficiency of such equipment to the extent that the net change will be a five to seven percent increase in electricity usage. The increased heat generated by this equipment will result in an additional four percent load on cooling and ventilating equipment. Thus, even an aggressive energy conservation program will result in a zero percent change in electrical consumption per square foot.

Transportation

The requirements for vehicular transportation in support of the University community are as varied as the programs of instruction, research and medical services fostered by this community.

Currently there are approximately 358 vehicles of various types in use by some 30 plus departments of offices of the University. There are eight departments having a fleet of 10 or more vehicles, these are the major transportation users having approximately 250 of the 358 vehicles.

In all cases the number of vehicles in use are directly related to the perceived level of support desired thus reductions in numbers of vehicles per se will come about only with program reductions.

With the advent of more fuel efficient vehicles on to the market, the use of more sophisticated maintenance equipment and better fleet management and bus scheduling it is believed that vehicle fuel consumption will be significantly reduced over the next 10 years. This reduction will result in 20% more passenger miles per gallon for busses and 30% more miles per gallon for other vehicles.

To meet these goals all University vehicles should eventually be centrally purchased, controlled and administered. This would assure that vehicle fleets are no larger than needed, and that the most effective and efficient vehicles are provided to meet job requirements.

Proper maintenance including exhaust gas analysis will be scheduled for all University vehicles to assure consistent fuel economy.

Public transportation requirements on the grounds will be periodically reviewed and adjusted to assure most effective use of busses.

Alternative fuels such as LNG or electric vehicles will be evaluated.

Summary

The preceding document states and explains three objectives for energy usage over the next ten years at the University of Virginia. These objectives will be met by two ways. First, using existing resources, modifications in engineering and design will be made to conserve energy. Secondly, using new resources (capital outlays) further savings of energy dollars will be achieved. The most savings on energy will occur through the latter technique. However, while the cost of energy saved will not be free, there will be reasonable payback period. The Department of Physical Plant estimates that this ten year plan can be achieved from a capital outlay of $25 to 30 millions of dollars with an average payback period of three years.

This document sets the boundary conditions on what will happen if no attempt is made to conserve energy as compared to what can happen if an effective energy management program is undertaken. The next step is to develop specific actions and projects to achieve the energy savings within these boundary conditions.

Attachment 1

Langford

A Comprehensive Facilities Management System: The University of Missouri Experience

By Mark D. Langford
and Michael H. Procter
University of Missouri

Fiscal crises at colleges and universities throughout the country lead to management crises. As institutional resources become progressively scarce relative to requirements, managers must ensure their institutions receive the biggest "bang for the buck" for resources invested in physical facilities. Fortunately, there is a countervailing development which promises to improve the quality of facilities management. Rapid advances in information technology and the advent of cheap computing power have made a whole new array of tools available to management. Facilities managers should recognize this opportunity and accept a major responsibility for exploiting the new information technology.

The University of Missouri is implementing computerized systems for facilities management. The University is a relatively large publicly supported multicampus system, but our experience is relevant to all types of institutions. A small private college encounters many of the same facilities management problems as we do. The University of Missouri uses the resources of a mainframe computer and a network of personal computers to operate its facilities management system. A small college may be able to operate a satisfactory system on a single personal computer, but the difference is mostly a technical detail and should not obscure the fundamental similarities.

The Facilities Management Problem

A facilities management system is a tool for use in solving an institution's overall facilities management problem. The management problem stems from the fact that resources are invariably scarce relative to an institution's requirements. The resources available to provide for new facilities and to provide for the remodeling, maintenance and operation of existing facilities are limited. The demands for these services, reflecting the real and perceived needs of students, faculty and staff, are effectively unlimited. Management's role is to see that scarce resources are used to do the best possible job of meeting these unlimited requirements.

Management has a dual responsiblity in fulfilling this role. Since resources are scarce relative to requirements, some requirements cannot be met. Management's first responsibility is to prioritize requirements and to choose among specific projects. Management's second responsibility is to see that resources are used to accomplish these priorities efficiently.

Basic Information Requirements

Managers must have ready access to pertinent information if they are to arrive at an acceptable solution to an institution's facilities management problem. Management information falls into three broad categories: the characteristics of existing facilities, the requirements for facilities and the resources required and available for facilities projects. Exhibit 1 describes these requirements in greater detail.

Regardless of the category, effective facilities information must be flexible. Detailed information improves the planning and tracking of specific projects and enhances credibility. At the same time, it has become a truism that modern information systems are capable of telling us more than we really want to know. Any computer worthy of the name is capable of generating massive reports of detailed information faster than any human being can interpret them. An effective information system must be flexible enough to summarize and analyze detailed information to arrive at "the bottom line" relevant to managers.

Facilities information should be shared by different users. The University of Missouri has four campuses (Columbia, Kansas City, Rolla and Saint Louis). Responsibilities for facilities management are shared among many groups at both the central administration and campus level. Historically, each group maintained its own facilities records. Policy discussions were frequently clouded by disagreements as to the basic facts. For this reason, the University has placed a heavy emphasis on the sharing of consistent facilities information. While this sharing of information has not always produced perfect agreement, it has ensured that different groups are talking about the same thing.

The problems the University experienced with inconsistent facilities information may be relatively extreme. Obviously, fewer actors are likely to be involved in facilities management at a small, single campus institution, but the difference is primarily one of degree. An institution must be very small indeed to assign the entire responsibility for facilities to a single individual.

Outline of a Comprehensive System

A comprehensive facilities management system satisfies management's basic information requirements more effectively than specialized systems which cannot "talk" to one another. While it is possible to design one system for maintenance, another system which schedules job orders and a third system which generates a capital budget, separate systems cannot take advantage of the fact the underlying information does not fall into three tidy categories. Operating three separate systems results in duplication of effort and opens the door for inconsistencies among the three closely related functions of maintenance, scheduling and budgeting.

A comprehensive facilities management system is made up of two elements: a repository of information or database and a set of uses for

Basic Information Requirements

Existing Facilities

Managers need to know what facilities an institution owns and manages, their present use, current condition and what resources are required to properly operate and maintain them

Facilities Requirements

Managers need to know the current and future needs (real or perceived) of students, faculty and staff

Resources

Managers need to know what resources (real and financial) are available, where those resources have been used in the past and how they can be most be most effectively used in the future

Exhibit 1

information or applications. Both elements are critical. A database without applications serves no purpose, but it is obviously impossible for an application to use information if there is no database.

The dual nature of a comprehensive system is sometimes a source of confusion. Some users may view the system in terms of the database, and think of it as a collection of files and data records. Others may view it from the applications point of view, thinking in terms of programs and reports. In reality, both views are correct.

Diagram 1 illustrates the major components of the University of Missouri facilities management system (FOCIP) from the database point of view. Exhibit 2 describes the various components in greater detail. The general areas of interest identified are relevant to most institutions.

Diagram 2 provides a breakdown of FOCIP from the applications point of view and Exhibit 3 provides a description of each component. Both the database and applications should be "tailored" to an institution, but applications may require more "customizing" than the database. Nonetheless, most institutions will have interests in the majority of the areas identified in Diagram 2 and Exhibit 3.

Automation and the New Information Technology

A comprehensive facilities management system could be implemented using familiar manual techniques, but manual systems are difficult to keep up to date and do not lend themselves to sharing by dispersed users. Manual operations are labor intensive by definition and may require unacceptable delays in retrieving specific information or in preparing analyses and reports. An effective automated system saves valuable staff time, is readily shared by different users, and is well suited to the rapid retrieval, updating, and analysis and reporting of information.

An automated system has the added advantage of "interfacing" or sharing information with other computerized systems which an institution may have in place. Interfacing with other computerized systems eliminates a costly duplication of effort and furthers the sharing of consistent information. The University of Missouri has computerized systems for student information, payroll/personnel data, financial accounting and accounts payable. The ability to "talk" to these other systems gives the facilities management system the flexibility to combine facilities data with other relevant information. Facilities managers can turn to a single source for most of their information needs.

Analysts frequently distinguish three phases in the history of the computer. Each phase corresponds to a major development in computer technology. The earliest phase was marked by the use of large and expensive mainframe computers. Access to the computer was limited both because computer time was extremely expensive and because the "input/output" devices available to communicate with the computer were relatively crude. If universities and colleges had an administrative computer at all, it was most likely dedicated to accounting-related applications.

Comprehensive Facilities Management System

Database

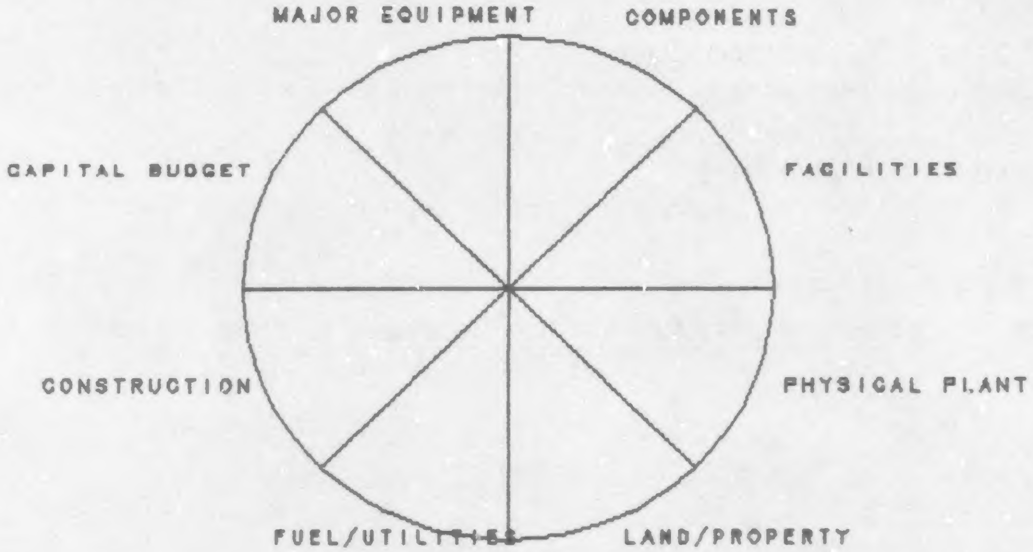

MAJOR EQUIPMENT
COMPONENTS
CAPITAL BUDGET
FACILITIES
CONSTRUCTION
PHYSICAL PLANT
FUEL/UTILITIES
LAND/PROPERTY

Diagram 1

Comprehensive Facilities Management System
Database

Facilities Inventory

An inventory of basic information on existing facilities

Facility Components and Major Equipment

An inventory of major building components such as roofing systems, HVAC, elevators, etc.

Capital Budget

An inventory of pending capital projects

Major Construction

A family of files relating to construction projects, contractors, change orders, etc.

Fuel & Utilities

Historical data on energy consumption by campus

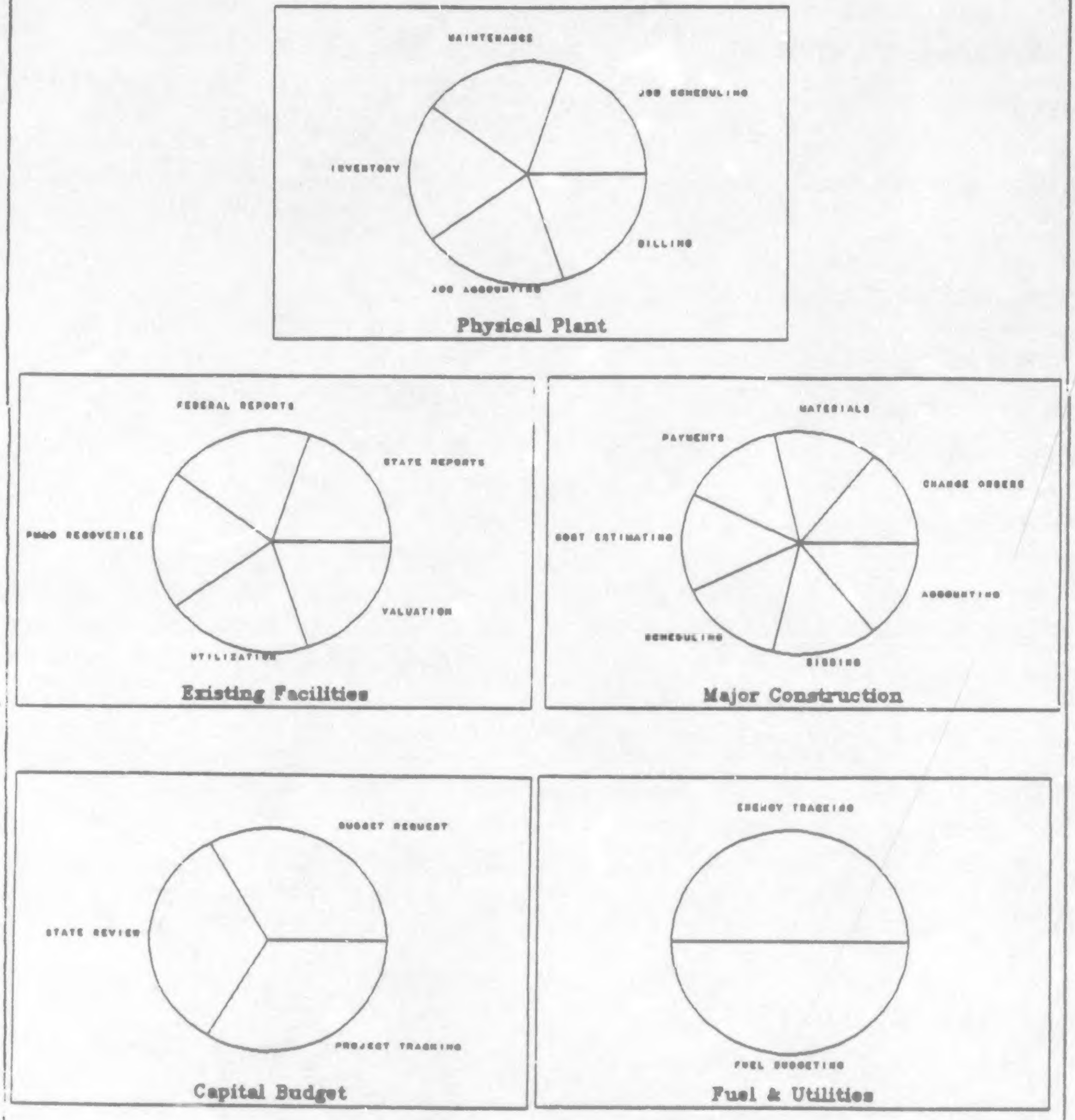
Physical Plant

A family of files relating to job orders, accounting, materials and personnel

Exhibit 2

Comprehensive Facilities Management System

Applications


MAINTENANCE
JOB SCHEDULING
INVENTORY
BILLING
JOB ACCOUNTING
FEDERAL REPORTS
STATE REPORTS
PMOO RECOVERIES
VALUATION
UTILIZATION
MATERIALS
PAYMENTS
CHANGE ORDERS
COST ESTIMATING
ACCOUNTING
SCHEDULING
BIDDING
BUDGET REQUEST
STATE REVIEW
PROJECT TRACKING
ENERGY TRACKING
FUEL BUDGETING

Physical Plant

Existing Facilities

Major Construction

Capital Budget

Fuel & Utilities

Diagram 2

Comprehensive Facilities Management System

Applications

Physical Plant

Job Scheduling
Maintenance Scheduling
Inventory Control
Job Accounting
Billing

Existing Facilities

State Reporting Requirements
Federal Reporting Requirements
Recovery of Plant, Maintenance and Operating Expense
Space Utilization Studies
Facilities Valuation for Replacement Cost and Insurance

Major Construction

Project Accounting
Change Order Tracking
Materials Inventory
Contractor and Consultant Payments
Cost Estimating
Scheduling
Bidding

Capital Budget

Preparation of Annual Budget Request
Tracking of Request through State Review
Tracking of Capital Projects after Funding

Fuel & Utilities

Tracking of Energy Consumption
Projection of Fuel and Utility Budgets

Exhibit 3

Programming and database management were generally the exclusive province of a central management information system (MIS) department. End users relied upon this group to develop and manage computer applications. Frequently, available programming and computer resources were inadequate to keep up with the demands of end users. The dreaded phrase, "applications backlog" came into use.

The next phase was characterized by the emergence of the minicomputer. As the technology improved, relatively modest and inexpensive systems were developed with the capabilities of earlier mainframes. Unlike the general purpose mainframe, minicomputers were frequently devoted to one or two specific applications. The new systems were more "user friendly" since they usually provided for direct or "on-line" access to the computer through a terminal as opposed to "batch" access using punched cards or paper tape.

Mainframes continued to develop during this period as well. Capacities increased at an exponential rate while costs decreased. Manufacturers responded to the challenge of the minicomputer by implementing "time sharing" which enabled many different users to have direct access to the computer simultaneously.

The usual effect of the minicomputer was to fragment computing. Departments which could afford a mini frequently turned to outside vendors to provide software and hardware. Communication and information exchanges with other users and with the central MIS department were usually limited. The central MIS department continued to focus on large scale applications such as accounting and student information while the applications backlog grew.

The microcomputer is the hallmark of the latest phase. Today's microcomputers have more capabilities than the earliest mainframes, but can be purchased for what one would have paid for only a few seconds of time on those early machines. Microcomputers have entered many homes disguised as video games and have entered most work places disguised as word processors. General purpose machines, dubbed "personal computers" are becoming commonplace. Stand-alone microcomputers have the capabilities to support many facilities management applications. A fairly elaborate system can be readily assembled for less than $10,000, and an adequate system for much less.

It is doubtful, however, that current stand-alone micros provide a complete solution for any but the smallest institutions. For most users, micros will come into their own when linked up with other microcomputers in "local area networks" and when linked with an institution's main computers. Local area networking permits different users to share relatively expensive "computer peripherals" such as printers and plotters. More importantly, networks permit different users to share information. A "gateway" to an institution's mainframe computer permits the user to draw upon databases such as an institution's financial system, permits facilities managers to share information with other institutional managers, and allows the micro user to draw upon the capabilities and resources of the mainframe if needed.

Some MIS departments have wholeheartedly embraced the microcomputer as the long awaited solution to the applications backlog. Others, pointing to the loss of central control and the general ignorance of end users, have been openly hostile to the microcomputer. Some private corporations have even gone to the extreme of banning the microcomputer.

The Need For User Entrepreneurship

Because some central MIS departments are openly hostile to the new information technology and because the applications backlog facing these departments continues to grow, facilities managers have little choice but to assume a major responsibility for implementing their own system. This requires a new entrepreneurial attitude toward computing.

In the language of the economist, "entrepreneurship" is the resource which combines the other resources of land, labor and capital in organizing production. Entrepreneurship requires non-routine decision-making, innovation, and the willingness to assume risk. Effective facilities managers are gifted with entrepreneurial ability even if most would not choose to describe their talents in that way. Facilities managers who are used to organizing the large investments in land, labor and capital required to construct and operate a college or university can and should use their skills to organize an effective facilities management system if the experts cannot or will not.

Even if the central MIS department is extremely cooperative, there is a need for heavy user involvement. Effective computer systems are designed by the end users and not by the computing experts. This is not necessarily due to any shortcoming on the part of the experts, but rather to the fact that it is the end user who best knows the requirements for a system and who must live with the system when it is in place.

Specific Applications

Most managers are interested in a facilities management system for what it can do (for its applications). The remainder of this paper focuses on some of the specific applications of FOCIP, the facilities management system at the University of Missouri.

Capital Budget

The University submits a capital budget request to the State of Missouri each year. After review by various executive agencies, the budget is submitted to the Missouri Legislature. Historically, preparation of the budget request was a lengthy and labor-intensive undertaking. Valuable staff time was consumed in assembling and sorting information on specific capital projects. Totalling and checking project and program costs required days of staff time. Inflation adjustments were done manually, which introduced a category of error which was difficult to detect with casual observation. Simply typing and proofreading the request document required extensive use of clerical time. These problems were aggravated by the fact that each year's budget request began essentially anew. Although deferred projects were carried over from previous budgets, most of the work involved in documenting these projects had to be repeated.

The basic product of this effort was a single, general purpose document. Tracking of the request as it progressed through executive and legislative review was done manually. After projects were approved and funded, no mechanism existed for tracking state funded projects in a systematic manner. The frequent result was a flurry of activity to transfer or encumber funds at the end of the fiscal year.

FOCIP provided an automated alternative to this manual process. The result has been a dramatic reduction in the management and clerical time invested in generating the budget request. The record keeping functions of sorting and classifying are handled by the computer. Calculations are performed rapidly and with nearly perfect accuracy. Clerical time is saved in preparing the budget request document. Finally, since the system retains information from previous budget requests and performs automatic inflation adjustments, it is able to "roll over" deferred projects with a minimum of human intervention.

The products of the automated system are much more flexible and varied than the single general purpose document resulting from the manual process. The process begins with a computer generated data entry sheet for use by field personnel (Figure 1). A series of data entry screens (Figure 2) are used by field personnel to enter new projects and to revise existing projects at a computer terminal. As the annual field review continues, campus personnel are furnished with a "turnaround document" (Figure 3) which permits them to verify information while the review is still fresh in their minds.

Figure 4 is a sample from the actual budget request. A link between FOCIP and automated typesetting equipment at the University's printing department is used to prepare a formal presentation edition of the request (Figure 5). As the executive and legislative review process continues, FOCIP provides a number of flexible specialized reports for internal use in tracking the request. Figure 6 presents an example of such a report, a summary of amounts requested by the University compared to amounts recommended by the Governor. Figure 7 provides examples of other specialized reports by type of project.

Once projects are funded, management must monitor individual projects and the program as a whole to ensure that work is completed on time and within budget. By linking information from the University's financial accounting system with information from the facilities management database, FOCIP can produce a number of project tracking reports. Figure 8 is an example of such a report. Use of these reports has resulted in greater management control over projects and a substantial reduction in adjustments at the end of the fiscal year.

FOCIP is also capable of producing a great variety of specialized reports of interest to management which are only peripherally related to the budget request. Figure 9 is a breakdown of capital projects by building and class of work, showing total number of projects and total dollar amount within each category. Diagram 3 presents a graphical breakdown of projects for a particular building by exterior, interior and mechanical/plumbing work. Diagram 4 is a graph of projected monthly expenditures for capital items which was produced in response to a State

FIGURE 1

DATA ENTRY SHEET FOR NEW PROJECTS TO FOCIP I FILE

ENTERED: ____ PREPARED BY: ______________________

DATE: __/__/__

REF. NUM: 10735

DESC: ____

-----JUSTIFICATION-----

CAMPUS: 37-(COLUMBIA)

SITE: __-(______________________)

BUILDING: ___-(______________________)

CLASS: _-(______________________)

TYPE: __-(______________________)

FUND(S/L): _ (S=STATE L=LOCAL)

C/O: _ (C=CAP. O=OPER)

ACSC: _ (A=YES BLANK=NO)

FY REQUESTED: __

PRIORITY: __ (A,B,C,D,E)

ENERGY SAVINGS: _.___ BTU/SF/DD

SIMPLE PAYBACK: _._

JO/PROJ #: ________

STAGE: A

INDIVIDUAL ITEMS

SRN	ACTION	SIZE/DESC	ITEM#	ITEM NAME	# UNITS	UNITS	UNIT COST
1	___	_________	_____	(______________________________)	_______	(___)	_______.__
2	___	_________	_____	(______________________________)	_______	(___)	_______.__
3	___	_________	_____	(______________________________)	_______	(___)	_______.__
4	___	_________	_____	(______________________________)	_______	(___)	_______.__
5	___	_________	_____	(______________________________)	_______	(___)	_______.__
6	___	_________	_____	(______________________________)	_______	(___)	_______.__
7	___	_________	_____	(______________________________)	_______	(___)	_______.__
8	___	_________	_____	(______________________________)	_______	(___)	_______.__
9	___	_________	_____	(______________________________)	_______	(___)	_______.__
10	___	_________	_____	(______________________________)	_______	(___)	_______.__

CLASSES
0=PRESERVATION
1=LIFE SAFETY/CODE
2=HANDICAPPED I
3=HANDICAPPED II
4=ENERGY
5=CAP IMPROVEMNT
6=NEW CONSTRUCT
7=HAZ. WASTE
8=MAJOR RENOVATION
9=CAPITAL EQUIP

TYPES
00=ROOFS
01=BLDG EXT
02=BLDG INT
03=MECH/PLUMB
04=ELECTRICAL
05=LIFE SAFETY
04=EXT SITE
05=UTILITY DIST
06=POWER PLANT
99=GENERAL

FIGURE 2

```
****************************     FOCIP      *****************************
                        NEW PROJECT INFORMATION
*************************************************************************

 CAMPUS                   =====>

 REFERENCE NUMBER         =====>
 DESCRIPTION              =====>
 SITE                     =====>
 BUILDING NUMBER          =====>
 CLASS                    =====>
 TYPE                     =====>
 STATE / LOCAL            =====>
 CAPITAL / OPERATING      =====>
 ACSC                     =====>
 REQUEST YEAR             =====>
 PRIORITY                 =====>
 ENERGY SAVINGS           =====>
 PAYBACK                  =====>
 JOB PROJECT NUMBER       =====>
 STAGE                    =====>

*************************************************************************
```

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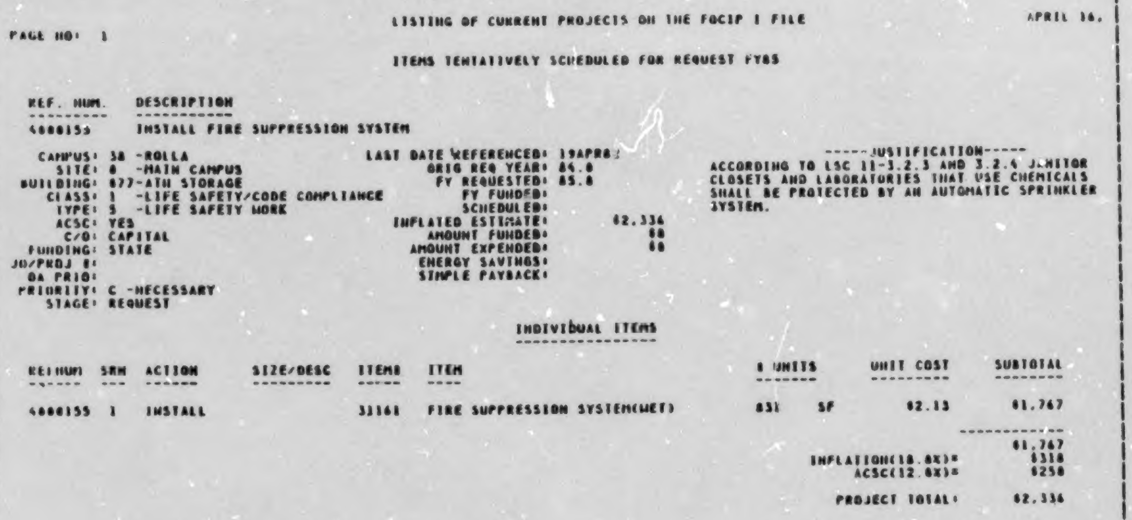

```
                                   LISTING OF CURRENT PROJECTS ON THE FOCIP I FILE                          APRIL 16,
PAGE NO:  1

                                   ITEMS TENTATIVELY SCHEDULED FOR REQUEST FY85

 REF. NUM.   DESCRIPTION
 ---------   -----------
 4000155     INSTALL FIRE SUPPRESSION SYSTEM

   CAMPUS: 38 -ROLLA                    LAST DATE REFERENCED: 19APR83              -----JUSTIFICATION-----
     SITE: 0  -MAIN CAMPUS                   ORIG REQ YEAR: 84.0          ACCORDING TO LSC 11-3.2.3 AND 3.2.4 JANITOR
 BUILDING: 077-ATH STORAGE                    FY REQUESTED: 85.0          CLOSETS AND LABORATORIES THAT USE CHEMICALS
    CLASS: 1  -LIFE SAFETY/CODE COMPLIANCE       FY FUNDED:               SHALL BE PROTECTED BY AN AUTOMATIC SPRINKLER
     TYPE: 5  -LIFE SAFETY WORK                  SCHEDULED:               SYSTEM.
     ACSC: YES                          INFLATED ESTIMATE:       $2,336
      C/O: CAPITAL                          AMOUNT FUNDED:           $0
  FUNDING: STATE                          AMOUNT EXPENDED:           $0
 JO/PROJ #:                                ENERGY SAVINGS:
  DA PRIO:                                 SIMPLE PAYBACK:
 PRIORITY: C -NECESSARY
    STAGE: REQUEST

                                              INDIVIDUAL ITEMS
                                              ----------------

 REFNUM  SRN  ACTION      SIZE/DESC   ITEM#  ITEM                               # UNITS     UNIT COST    SUBTOTAL
 ------  ---  ------      ---------   -----  ----                               -------     ---------    --------

 4000155  1   INSTALL                 31161  FIRE SUPPRESSION SYSTEM(WET)       831   SF       $2.13      $1,767
                                                                                                       -----------
                                                                                                          $1,767
                                                                                    INFLATION(18.0%)=       $318
                                                                                         ACSC(12.0%)=       $250

                                                                                      PROJECT TOTAL:      $2,336
```

FIGURE 3

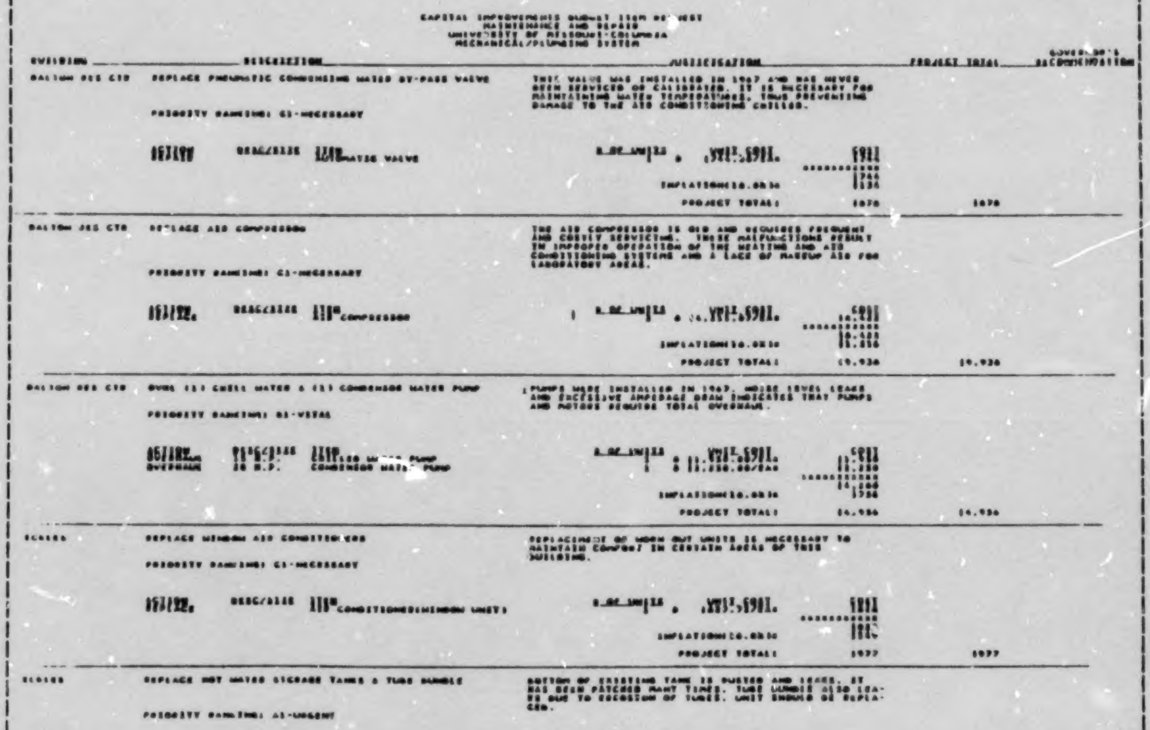

FIGURE 4

FIRE STATION — **PAINT EXTERIOR DOORS, TRIM & WINDOWS**

JUSTIFICATION: THE PAINT ON THE TRIM, DOORS AND WINDOWS OF THIS STRUCTURE IS PEELING AND CHIPPING OFF. THIS BUILDING HAS NOT BEEN PAINTED IN OVER 8 YEARS AND MUST NOW BE PAINTED OR FURTHER DAMAGE WILL OCCUR TO THE WOOD.

PRIORITY RANKING: B2 - VITAL

ACTION	DESC/SIZE	ITEM	NO. OF UNITS		UNIT COST	COST
PAINT		TRIM & APPURTENANCES	1,462 SF	@	$0.70/SF =	$1,023
						$1,023
					INFLATION:	$184
					ACEC:	$146
					PROJECT TOTAL:	$1,353

GEOLOGY — **PAINT EXTERIOR DOORS, TRIM & WINDOWS**

JUSTIFICATION: THE PAINT ON THE TRIM, DOORS AND WINDOWS OF THIS STRUCTURE IS PEELING AND CHIPPING OFF. THIS BUILDING HAS NOT BEEN PAINTED IN OVER 8 YEARS AND MUST NOW BE PAINTED OR FURTHER DAMAGE WILL OCCUR TO THE WOOD.

PRIORITY RANKING: C1 - NECESSARY

ACTION	DESC/SIZE	ITEM	NO. OF UNITS		UNIT COST	COST
PAINT		TRIM & APPURTENANCES	3,218 SF	@	$0.70/SF =	$2,253
						$2,253
					INFLATION:	$405
					PROJECT TOTAL:	$2,658

GEOLOGY — **TUCKPOINT CORNER STONE AND COPING STONE**

JUSTIFICATION: THIS TUCKPOINTING IS REQUIRED TO STOP AND PREVENT MOISTURE FROM PENETRATING EXISTING WALLS AND DAMAGING THE INTERIOR OF THE BUILDING.

PRIORITY RANKING: C1 - NECESSARY

ACTION	DESC/SIZE	ITEM	NO. OF UNITS		UNIT COST	COST
TUCKPOINT		EXTERIOR SURFACE(STONE)	410 LF	@	$2.00/LF =	$820
						$820
					INFLATION:	$148
					PROJECT TOTAL:	$968

GWYNN — **PAINT EXTERIOR DOORS, TRIM & WINDOWS**

JUSTIFICATION: THE PAINT ON THE TRIM, DOORS AND WINDOWS OF THIS STRUCTURE IS PEELING AND CHIPPING OFF. THIS BUILDING HAS NOT BEEN PAINTED IN OVER 8 YEARS AND MUST NOW BE PAINTED OR FURTHER DAMAGE WILL OCCUR TO THE WOOD.

PRIORITY RANKING: C1 - NECESSARY

ACTION	DESC/SIZE	ITEM	NO. OF UNITS		UNIT COST	COST
PAINT		TRIM & APPURTENANCES	5,891 SF	@	$0.70/SF =	$4,124
						$4,124
					INFLATION:	$742
					PROJECT TOTAL:	$4,866

GWYNN — **TUCKPOINT 18 BRICK CHIMNEYS**

JUSTIFICATION: THE MORTAR JOINTS ARE STARTING TO SHOW SIGNS OF DETERIORATION AND SHOULD BE TUCKPOINTED BEFORE JOINTS BECOME OPEN AND START TO ABSORB MOISTURE. THE UNIT COST IS HIGH BECAUSE IT IS BASED ON SMALL SQUARE FEET OF EACH UNIT.

PRIORITY RANKING: C1 - NECESSARY

ACTION	DESC/SIZE	ITEM	NO. OF UNITS		UNIT COST	COST
TUCKPOINT	CHIMNEYS	EXTERIOR SURFACE(BRICK)	850 SF	@	$4.50/SF =	$3,825
INSTALL		SCAFFOLDING	1	@	$500.00/EA =	$500
REPLACE	CHIMNEY	FLASHING & COUNTERFLASHING	90 LF	@	$5.00/LF =	$450
						$4,775
					INFLATION:	$860
					PROJECT TOTAL:	$5,635

HEARNES — **RECAULK PRECAST EXTERIOR CONCRETE WALL PANELS**

JUSTIFICATION: CAULKING WAS ORIGINALLY INSTALLED IN 1960 AS PART OF THE ORIGINAL CONSTRUCTION. IT HAS HARDENED AND IS STARTING TO PULL AWAY FROM THE SIDES OF THE JOINTS LEAVING CRACKS FOR MOISTURE PENETRATION.

PRIORITY RANKING: D1 - HIGHLY DESIRABLE

ACTION	DESC/SIZE	ITEM	NO. OF UNITS		UNIT COST	COST
CAULK	CRACKING	EXTERIOR SURFACE(CONCRETE)	13,440 LF	@	$2.00/LF =	$26,880
						$26,880
					INFLATION:	$4,838
					PROJECT TOTAL:	$31,718

HILL HALL — **PAINT EXTERIOR DOORS, TRIM & WINDOWS**

JUSTIFICATION: THE PAINT ON THE TRIM, DOORS AND WINDOWS OF THIS STRUCTURE IS PEELING AND CHIPPING OFF. THIS BUILDING HAS NOT BEEN PAINTED IN OVER 8 YEARS AND MUST NOW BE PAINTED OR FURTHER DAMAGE WILL OCCUR TO THE WOOD.

PRIORITY RANKING: C1 - NECESSARY

ACTION	DESC/SIZE	ITEM	NO. OF UNITS		UNIT COST	COST
PAINT		TRIM & APPURTENANCES	7,660 SF	@	$0.70/SF =	$5,362
						$5,362
					INFLATION:	$965
					ACEC:	$750
					PROJECT TOTAL:	$7,080

HILL HALL — **TUCKPOINT ALL COPING, BELT AND CUT STONE**

JUSTIFICATION: WHILE THE BRICK JOINTS ARE FAIRLY SOLID, THE JOINTS OF ALL THE CUT STONE ARE SHOWING SIGNS OF DETERIORATION.

PRIORITY RANKING: C1 - NECESSARY

ACTION	DESC/SIZE	ITEM	NO. OF UNITS		UNIT COST	COST
TUCKPOINT		COPING STONE	11,240 SF	@	$4.10/SF =	$46,107
						$46,107
					INFLATION:	$8,660
					PROJECT TOTAL:	$54,766

FIGURE 5

```
                              ** ROLLA CAMPUS **                    18:11 TUESDAY, MARCH 8, 1983
             SUMMARY OF PROJECTS RECOMMENDED BY THE GOVERNOR FOR FY 1983-84
------------------------------- CLASS=PRESERVATION   TYPE=BUILDING EXTERIOR WORK ------------------------------

 BLDGNAME            REFNUM   DESC
                                                                      REQYEAR  FUNDYEAR   ESTIMATE     FUNDED

 BUILDING B         4000111   SANDBLAST,TUCKPOINT AND EXTERIOR PAINTING  84       84      $12,102    $12,102
 BUILDING C         4000156   PAINT EXTERIOR                            84       84       $1,558     $1,558
 BULLMAN M-P BLD        799   PAINT EXTERIOR                            84       83       $2,288         $0
 ELECTRICAL ENGR        801   PAINT EXTERIOR                            84       84       $1,256     $1,256
 HARRIS                 805   PAINT EXTERIOR                            84       83       $1,681         $0
 KUMR TRANSMIT      4000085   EXTERIOR PAINTING                         84       84         $766       $766
 MATH-COMP SCI      4000267   INSTALL FOOTING DRAIN,REPAIR PATIO,MISC. TUCKPOINT 84 84    $34,027    $34,027
 MECHANICAL ENGR        803   PAINT EXTERIOR                            84       83       $1,874         $0
 MINE COMP HOUSE    4000149   TUCKPOINT EXTERIOR CRACKS                 84       84       $3,369     $3,369
 MINE DRY HOUSE     4000146   PAINT EXTERIOR                            84       83         $467         $0
 MINE VENT LAB      4000151   TUCKPOINT AND PAINT EXTERIOR              84       84       $2,850     $2,850
 POWER PLANT            800   PAINT EXTERIOR                            84       84       $2,233     $2,233
 PRESS BOX          4000186   PAINT METAL FRAMEWORK-EAST SIDE OF STAD.BLEACHERS 84 84     $23,680    $23,680
 ROCK MECHS CTR     4000088   CLEAN & WATERPROOF BRICK PAINT WINDOWS & TRIM 84   84      $69,384    $69,384
 ROCK MECHS CTR     4000090   REPLACE STORM WINDOWS                     84       84       $2,212     $2,212
 ROCK MECHS CTR     4000092   BRICK WINDOWS, FIX SOFFIT, REPLACE GUTTERING 84    84       $7,207     $7,207
 STRAUMANIS HALL        802   PAINT EXTERIOR                            84       84         $991       $991
 T-1                4000252   REPLACE DOORS,REPAIR SIDING, & PAINT EXTERIOR 84   83       $4,648         $0
 T-23               4000143   CONCRETE REPAIRS AND TUCKPOINTING         84       84       $9,938     $9,938
 T-14               4000152   TUCKPOINT AND PAINT EXTERIOR              84       84       $1,995     $1,995
 TEMP RESCH FAC         804   PAINT EXTERIOR                            84       84         $623       $623
 TEMP RESCH FAC     4000114   WEATHER STRIP SERVICE DOORS               84       84         $177       $177
 ---------------                                                                        ---------  ---------
 TYPE                                                                                   $184,428   $174,278

------------------------------- CLASS=PRESERVATION   TYPE=BUILDING INTERIOR WORK ------------------------------

 BLDGNAME            REFNUM   DESC
                                                                      REQYEAR  FUNDYEAR   ESTIMATE     FUNDED

 BUEHLER                757   PAINTING AND MINOR PLASTER REPAIR         84       84       $8,153     $8,153
 BUILDING D         4000098   PAINT INTERIOR                            84       83       $2,971         $0
 BULLMAN M-P BLD        752   INTERIOR PAINTING                         84       84      $25,770    $25,770
 BULLMAN M-P BLD    4000108   REPAIR CRACKS IN PLASTER,PAINT MULTI-PURPOSE 84    84       $6,490     $6,490
 COMP FLUID LAB         758   PAINTING AND MINOR PLASTER REPAIR         84       83         $941         $0
 DRESS FACILITY     4000101   PAINT INTERIOR OF DRESSING FACILITY       84       83       $2,303         $0
 ELECTRICAL ENGR    4000301   REMOVE AND REPLACE CERAMIC TILE IN STAIRWELLS 84   84         $823       $823
 ENGR RESCH LAB     4000256   PAINT INTERIOR WALLS AND REPAIR CEILING   84       83       $2,698         $0
 KUMR TRANSMIT          755   PAINTING AND MINOR PLASTER REPAIR         84       83         $800         $0
 MATH COMP SCI          751   PAINTING AND MINOR PLASTER REPAIR         84       83      $22,469         $0
 MATH COMP SCI      4000268   MISC TUCKPOINTING & RECAULK EXPANSION JOINTS 84    84         $463       $463
 MECHANICAL ENGR        754   PAINTING AND MINOR PLASTER REPAIR         84       84      $23,918    $23,918
 MINE COMP HOUSE    4000147   PAINT INTERIOR                            84       83       $1,388         $0
 UCW CAFETERIA      4000243   PAINT BUILDING INTERIOR                   84       83       $5,731         $0
 POWER PLANT        4000292   PAINT BOILER RM,TURBINE ROOM FLOOR & CONTROL PANEL 84 83    $12,753         $0
 ROCK MECHS CTR     4000089   REPAIR & REPAINT INTERIOR WALLS OF ROCK MECHANICS 84 83     $11,836         $0
 STRAUMANIS HALL        753   PAINTING AND MINOR PLASTER REPAIR         84       84      $15,878    $15,878
 STRAUMANIS HALL    4000116   INTERIOR WALL REPAIRS                     84       84       $3,982     $3,982
 STRAUMANIS HALL    4000124   REPAIR CONCRETE FLOOR AND VINYL TILE      84       84       $7,670     $7,670
 T-1                4000253   PAINT INTERIOR                            84       83       $4,457         $0
 T-2                4000238   REPLACE CORRIDOR VINYL FLOOR TILES        84       84         $442       $442
```

FIGURE 6

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                                          ** ROLLA CAMPUS **                                       18:11 TUESDAY, MARCH 8, 1983   18
                  SUMMARY OF HANDICAPPED ACCESSIBILITY PROJECTS RECOMMENDED BY THE GOVERNOR FOR FY1983-84

        P    B                                                                                        F             E
  D     R    L                                                                                 R      U             S
  A     I    D                      R                                                          E      N             T          F
  _     O    G                      E                                                          Q      D             I          U   S
  P     R    N                      F   D                                                      Y      Y             M          N   T
  R     I    A                      N   E                                                      E      E             A          D   A
  I     T    M                      U   S                                                      A      A             T          E   G
  O     Y    E                      M   C                                                      R      R             E          D   E

82-01        ENGR RESCH LAB      302   INSTALL TACTILE SIGNS AT DOORWAYS & ELEVATORS          84     84        $1,416    $1,422   REQUEST
82-01        NUCLEAR REACTOR     309   MODIFY RESTROOMS AND INSTALL WATER FOUNTAINS           84     84        $6,314    $6,320   REQUEST
82-04        NUCLEAR REACTOR     307   DESIGNATE PARKING SPACES AND INSTALL RAMP              84     84        $5,727    $5,733   REQUEST
82-04        NUCLEAR REACTOR     306   INSTALL VISUAL FIRE ALARMS IN CORRIDORS                84     84          $519      $525   REQUEST
84-01        B-C CIVIL ENGR      643   INSTALL ELEVATOR                                       84      .       $91,091        $0   UNDETERMINED
84-01        BULLMAN M-P BLD     650   INSTALL ELEVATOR                                       84      .       $91,091        $0   UNDETERMINED
84-01        BULLMAN M-P BLD     651   INSTALL TACTILE SIGNS                                  84      .          $850        $0   UNDETERMINED
84-01        ELECTRICAL ENGR     626   INSTALL TACTILE SIGNS                                  84      .          $850        $0   UNDETERMINED
84-01        ENGR MECHS BLDG     613   INSTALL TACTILE SIGNS                                  84      .          $354        $0   UNDETERMINED
84-01        HUMAN-SOC SCI       644   INSTALL TACTILE SIGNS                                  84      .        $1,416        $0   UNDETERMINED
84-04        GENERAL SITE        646   PROVIDE ACCESS FOR HANDICAPPED AT NEW SOCCER FIELD     84      .          $470        $0   UNDETERMINED
84-04        B-C CIVIL ENGR      604   INSTALL TACTILE SIGNS                                  84      .          $850        $0   UNDETERMINED
84-04        B-C CIVIL ENGR      605   INSTALL SPECIAL LAB EQUIPMENT                          84      .       $16,822        $0   UNDETERMINED
84-04        ELECTRICAL ENGR     629   INSTALL SPECIAL LAB STATIONS                           84      .       $16,822        $0   UNDETERMINED
84-04        HUMAN-SOC SCI       645   INSTALL SPECIAL LAB STATIONS                           84      .       $14,719        $0   UNDETERMINED
84-04        MATH-COMP SCI       651   INSTALL TACTILE SIGNS                                  84      .        $1,416        $0   UNDETERMINED
84-04        MECHANICAL ENGR     635   ***INSTALL SIGNS (TACTILE)                             84      .          $991        $0   UNDETERMINED
84-04        MECHANICAL ENGR     636   INSTALL SPECIAL LAB STATIONS                           84      .       $27,547        $0   UNDETERMINED
84-04        PARKER              623   INSTALL SPECIAL LAB STATIONS                           84      .        $3,154        $0   UNDETERMINED
84-05        STRAUMANIS HALL     632   INSTALL TACTILE SIGNS                                  84      .        $1,416        $0   UNDETERMINED
84-04        GENERAL SITE        647   MODIFY RESTROOMS AT NEW SOCCER FIELD                   84      .        $3,398        $0   UNDETERMINED
84-04        HUMAN-SOC SCI       642   ***INSTALL VISUAL FIRE ALARMS                          84      .        $1,817        $0   UNDETERMINED
                                                                                                          =========   =======
                                                                                                           $289,041   $14,000
```

```
                                          ** SAINT LOUIS CAMPUS **                                 18:11 TUESDAY, MARCH 8, 1983
                  SUMMARY OF HANDICAPPED ACCESSIBILITY PROJECTS RECOMMENDED BY THE GOVERNOR FOR FY1983-84

DA_PRIO  PRIORITY  BLDGNAME         REFNUM  DESC                                   REQYEAR  FUNDYEAR  ESTIMATE  FUNDED    STAGE

 84-02             BENTON HALL        658   INSTALL SPECIAL LAB STATIONS             84        .       $26,705    $0     UNDETERMINED
 84-02             WOODS HALL         683   MODIFY RESTROOMS                         84        .        $2,848    $0     UNDETERMINED
 84-03             CLARK HALL         666   INSTALL TACTILE SIGNS                    84        .          $771    $0     UNDETERMINED
 84-03             EDUC LIBRARY       680   INSTALL TACTILE SIGNS                    84        .           $78    $0     UNDETERMINED
 84-03             LUCAS HALL         669   INSTALL TACTILE SIGNS                    84        .          $701    $0     UNDETERMINED
 84-03             SOC SC BUS BLDG    673   INSTALL TACTILE SIGNS                    84        .        $1,482    $0     UNDETERMINED
 84-03             STADLER HALL       661   INSTALL TACTILE SIGNS                    84        .          $701    $0     UNDETERMINED
 84-04             EDUC CLRM BLDG     689   INSTALL AUDIO-VISUAL FIRE ALARM          84        .          $130    $0     UNDETERMINED
 84-04             J C PENNEY         692   INSTALL AUDIO-VISUAL FIRE ALARMS         84        .          $519    $0     UNDETERMINED
 84-04             MARK TWAIN BLDG    686   INSTALL AUDIO-VISUAL FIRE ALARMS         84        .          $389    $0     UNDETERMINED
 84-05             LUCAS HALL         670   INSTALL SPECIAL LAB UNITS                84        .       $21,028    $0     UNDETERMINED
 84-05             SOC SC BUS BLDG    674   INSTALL SPECIAL LAB STATIONS             84        .       $21,028    $0     UNDETERMINED
 84-05             STADLER HALL       662   INSTALL SPECIAL LAB STATIONS             84        .       $18,083    $0     UNDETERMINED
 84-05             J C PENNEY         693   MODIFY RESTROOMS                         84        .       $10,370    $0     UNDETERMINED
 84-05             MARK TWAIN BLDG    687   MODIFY RESTROOMS                         84        .       $10,994    $0     UNDETERMINED
 84-06             WOODS HALL         684   INSTALL TACTILE SIGNS                    84        .          $526    $0     UNDETERMINED
 84-07             EDUC CLRM BLDG     691   INSTALL TACTILE SIGNS                    84        .          $351    $0     UNDETERMINED
 84-07             J C PENNEY         694   INSTALL TACTILE SIGNS                    84        .          $841    $0     UNDETERMINED
 84-08             J C PENNEY         695   INSTALL SPECIAL LAB EQUIPMENT            84        .          $736    $0     UNDETERMINED
 84-08             MARK TWAIN BLDG    688   INSTALL SPECIAL LAB EQUIPMENT            84        .          $288    $0     UNDETERMINED
 84-09             EDUC OFF BLDG      430   INSTALL SPECIAL LAB EQUIPMENT            84        .        $2,103    $0     UNDETERMINED
 84-12             OFFICE BUILDING    431   MODIFY BUILDING APPROACH                 84        .           $71    $0     UNDETERMINED
 84-13             OFFICE BUILDING    432   MODIFY RESTROOMS                         84        .        $4,277    $0     UNDETERMINED
 84-14             OFFICE BUILDING    433   INSTALL TACTILE SIGNS                    84        .          $288    $0     UNDETERMINED
                                                                                                      ========    ==
                                                                                                      $125,197    $0
```

FIGURE 7

```
             LISTING OF STATE PROJECTS FUNDED FOR FY1982-83          17:23 FRIDAY, MARCH 11, 1983
               BOTH REGULAR AND SUPPLEMENTAL APPROPRIATIONS
                SUMMARY OF FUNDS COMMITTED AND EXPENDED TO DATE
 NOTE: PROJECTS WITH A "-" IN THE FUNDED COLUMN ARE SUBSTITUTIONS NOT YET FORMALLY ACCEPTED BY UMCA

--------------------------- CAMPUS=COLUMBIA/CENTRAL ADMIN  FUNDYEAR=83.0  CLASS=PRESERVATION ---------------------------

BLDGNAME          REFNUM JOBPROJN DESC                                              FUNDED  COMMITED    EXPENDED PCT_EXP  STAGE

ABATTOIR              1  J33505   RESATURATE ROOF, REPAIR GUTTER                    $7,683    $7,683       $0.00     0   PRELIMINARY
AGRICULTURE LAB     172  J61307   REPAIR OR REPLACE CERAMIC & GLAZED TILE             $354      $354       $0.00     0   PRELIMINARY
CLARK HALL          143  J33309   REPLACE CARPET THROUGHOUT BUILDING               $15,297   $14,825       $0.00     0   PRELIMINARY
EDUCATION           175  J61305   REPAIR OR REPLACE CERAMIC & GLAZED TILE             $354      $698       $0.00     0   PRELIMINARY
ENGR COMPLEX        178  J61304   REPAIR OR REPLACE CERAMIC & GLAZED TILE             $354      $704       $0.00     0   PRELIMINARY
GENTRY HALL         169  J63411   PATCH PLASTER WALLS                                 $839      $839       $0.00     0   PRELIMINARY
HEARNES              42  J32609   REPLACE ELECTRIC MOTOR CONTACTS 1ST & 2ND LEVELS  $2,059    $2,059       $0.00     0   PRELIMINARY
HILL HALL           176  J61303   REPAIR OR REPLACE CERAMIC & GLAZED TILE             $354      $695       $0.00     0   PRELIMINARY
JESSE               177  J29205   REPAIR OR REPLACE CERAMIC & GLAZED TILE             $354      $354       $0.00     0   PRELIMINARY
LEFEVRE             166  J63402   PATCH PLASTER WALLS                                 $839      $839       $0.00     0   PRELIMINARY
LOW LEVEL           170  J63412   PATCH PLASTER WALLS                                 $839      $839       $0.00     0   PRELIMINARY
MCALESTER           165  J63403   PATCH PLASTER WALLS                                 $839      $839       $0.00     0   PRELIMINARY
MCKEE GYM           145  J31316   INSTALL EPOXY FLOOR IN SHOWER & DRESSING ROOMS    $5,947    $6,698       $0.00     0   PRELIMINARY
MEDICAL SCIENCE      38  663872   REPLACE LINING IN HOT WATER TANKS                 $9,735    $9,735       $0.00     0   PRELIMINARY
MEDICAL SCIENCE      39  663871   REPLACE CENTRAL VACUUM PUMPS & TANKS             $42,126   $42,126       $0.00     0   PRELIMINARY
MUMFORD             167  J63406   PATCH PLASTER WALLS                                 $839      $839       $0.00     0   PRELIMINARY
NEFF & ADDITION      46  J28513   REPLACE ELEC. PANELS & WIRE                      $10,620   $10,620       $0.00     0   PRELIMINARY
PARKER HALL         164  J63408   PATCH PLASTER WALLS                                 $839    $3,234       $0.00     0   PRELIMINARY
SCHWEITZER         2600  J29203   REPAIR BLISTERS AND RECOAT ROOF AND FLASHING        $922      $922       $0.00     0   PRELIMINARY
SF MAIN OFFICE       56  C47226   REPLACE WALK-IN COOLER LOCATED E. OF MAIN OFFICE $14,406    $7,989       $0.00     0   PRELIMINARY
SOCIOLOGY           162  J63409   PATCH PLASTER WALLS                                 $839      $839       $0.00     0   PRELIMINARY
SWALLOW             163  J63410   PATCH PLASTER WALLS                                 $839      $839       $0.00     0   PRELIMINARY
1-14                 52  J32613   REPLACE ELEC. PANELS & WIRE                      $11,870   $11,800       $0.00     0   PRELIMINARY
WALTER WILLIAMS     201  J29202   REPAIR BLISTERS AND RECOAT ROOF AND FLASHING        $323      $323       $0.00     0   PRELIMINARY
401 E. STEWART       32  J32614   REPLACE FUSE PANELS & WIRE                       $15,659   $15,659       $0.00     0   PRELIMINARY
HEARNES              15  2076     MODIFY ROOF TRUSSES TO STRENGTHEN BUILDING      $203,903   $14,988  $14,987.72   100   FINALS
ACAD SUP CENTER    1000  J33504   REPAIR BLISTERS AND RECOAT ROOF AND FLASHING      $8,114    $8,114   $6,442.35    79   IN PROGRESS
ARTS & SCIENCE       27  J28416   REPLACE AUTO VALVES & REPAIR LEAKS IN AIR LINES  $17,700   $17,700   $3,365.33    19   IN PROGRESS
BREWER F H          183  J64006   REPLACE DAMAGED FLOOR TILE                          $330      $330     $308.47    93   IN PROGRESS
DALTON RES CTR      192  J29207   REPLACE DAMAGED CEILING TILE                        $693      $693     $354.31    51   IN PROGRESS
ECKLES              171  J61306   REPAIR OR REPLACE CERAMIC & GLAZED TILE             $354      $354     $346.85    98   IN PROGRESS
GENERAL SITE        212  J61926   MAINTENANCE ON STEAM SYSTEM TO REACTOR & HOSPITAL $47,200   $47,200     $438.00     1   IN PROGRESS
GENERAL SITE        213  SFM30001 MAINTENANCE ON STORM AND SEWER SYSTEM            $15,791   $25,930  $14,618.12    56   IN PROGRESS
GWYNN               193  J29206   REPLACE DAMAGED CEILING TILE                        $693      $693     $431.08    62   IN PROGRESS
JESSE               194  J29506   REPLACE DAMAGED CEILING TILE                        $693      $693     $686.73    99   IN PROGRESS
LEFEVRE            1700  J27718   REPAIR BLISTERS AND RECOAT ROOF AND FLASHING      $2,506    $2,506   $1,885.00    75   IN PROGRESS
MIDDLEBUSH BLDG      45  J32611   REPLACE ELEC. PANELS & WIRING THROUGHOUT BLDG.    $9,448    $9,448      $18.25     0   IN PROGRESS
NEW CHEMISTRY        28  J32610   OVERHAUL TEMP. CONTROLS                          $23,600   $23,600     $165.50     1   IN PROGRESS
NEW CHEMISTRY        29  J64011   REPLACE RESIN BED ON DEMINERALIZER                $2,360    $2,360     $656.91    28   IN PROGRESS
PARKER HALL         186  J64010   REPLACE DAMAGED FLOOR TILE                          $330      $330     $270.80    82   IN PROGRESS
POWER PLANT         214  SFM30002 DESIGN WORK TO REPLACE SUPERHEATER TUBES & WELLS $11,855    $1,704   $1,704.02   100   IN PROGRESS
REACTOR             191  J29505   REPLACE DAMAGED CEILING TILE                        $693        $0       $0.00     0   IN PROGRESS
RES PARK DEV        132  J29204   RECONSTRUCT BRICK SCREEN WALL AROUND A/C UNIT     $4,613    $4,613   $2,628.07    57   IN PROGRESS
ROTHWELL GYM         48  J28515   REPAIR AUTO TEMPERATURE CONTROLS                  $5,900    $5,900   $1,480.72    25   IN PROGRESS
SCHLUNDT            173  J61913   REPAIR OR REPLACE CERAMIC & GLAZED TILE             $354      $354     $348.85    99   IN PROGRESS
SCHLUNDT ANNEX       49  J28412   REPLACE ELEC. PANELS & WIRE                       $6,986    $6,986   $2,318.28    33   IN PROGRESS
SCHLUNDT ANNEX      174  J61912   REPAIR OR REPLACE CERAMIC & GLAZED TILE             $354      $354     $347.25    98   IN PROGRESS
SOCIOLOGY           181  J29508   REPLACE DAMAGED FLOOR TILE                          $331    $1,026     $198.74    19   IN PROGRESS
STEWART HALL         58  J28517   REPLACE ELEC. PANELS & WIRE                      $10,620   $10,620     $707.11     7   IN PROGRESS
```

FIGURE 8

```
                                   -UNIVERSITY OF MISSOURI-
                 BUILDING PRESERVATION, MODERNIZATION AND RENOVATION REQUIREMENTS
                        SUMMARY OF PROJECT COSTS BY BUILDING AND TYPE OF PROJECT
                                        COLUMBIA CAMPUS

BLDGNAME           NUM_PROJ   PRESERVE   LIFESAFE   HANDICAP    ENERGY   RENOVATE       NEWCONST          TOTAL

ABATTOIR               1            $0     $6,935         $0        $0         $0             $0         $6,935
ACAD SUP CENTER        5       $34,288    $42,975         $0        $0         $0             $0        $77,263
AGR ENGR               5       $12,406    $37,540         $0        $0         $0             $0        $49,946
AGR ENGR LAB           2        $6,037    $12,971         $0        $0         $0             $0        $19,008
AGRICULTURE           21      $139,008   $107,538   $149,896        $0     $2,360             $0       $398,803
AGRICULTURE LAB        5       $69,825    $44,762         $0        $0         $0             $0       $114,587
ALUMNI CENTER          3       $36,503     $3,136         $0        $0         $0             $0        $39,640
AN SCI RES CTR         8       $76,793    $81,443         $0        $0         $0             $0       $158,236
ANIM MET BLDG          1            $0     $1,332         $0        $0         $0             $0         $1,332
ANIMAL PSY RES         7       $41,226     $8,291         $0        $0         $0             $0        $49,518
AP GREEN CHAPEL        1            $0    $19,972         $0        $0         $0             $0        $19,972
ARTS & SCIENCE         9       $29,927    $70,028     $2,805        $0     $2,360             $0       $105,120
BEEF BARN              1        $6,327         $0         $0        $0         $0             $0         $6,327
BOT-GH RES PARK        1        $5,162         $0         $0        $0         $0             $0         $5,162
BRADY COMMONS          1            $0    $50,262         $0        $0         $0             $0        $50,262
BREWER F H             7       $62,053    $15,766         $0        $0         $0             $0        $77,819
CHANCELLORS RES        1        $3,298         $0         $0        $0         $0             $0         $3,298
CUL PROF BLDG          4       $59,606   $143,052         $0        $0         $0             $0       $202,658
CONLEY HOUSE           1        $9,527         $0         $0        $0         $0             $0         $9,527
CONNAWAY              12       $18,234    $72,702         $0        $0    $57,855             $0       $148,791
CROWDER                8       $88,267    $78,229         $0        $0     $7,658             $0       $174,154
CURTIS                 7       $32,926    $94,305         $0        $0         $0             $0       $127,231
DALTON RES CTR        16      $133,218    $50,362         $0        $0     $4,720             $0       $188,300
OUT-DRK ATH FAC        1            $0     $7,812         $0        $0         $0             $0         $7,812
ECKLES                 9        $2,738   $140,188    $20,141    $7,003     $4,177             $0       $174,248
EDUCATION              8       $15,429    $94,232     $9,192        $0    $35,063             $0       $153,917
ELECTRICAL ENGR       13       $11,762    $85,778   $191,345        $0         $0             $0       $288,884
ELLIS LIBRARY         11       $51,825         $0         $0    $1,394    $35,164             $0        $88,383
ENGR COMPLEX          11      $160,678   $266,079     $1,402    $6,253         $0             $0       $434,412
FINE ARTS (ART)       13      $330,965    $69,836   $131,063        $0         $0             $0       $531,865
FINE ARTS (MED)        4       $22,120    $23,237         $0        $0         $0             $0        $45,356
FIRE STATION           5        $6,099     $5,269         $0        $0     $3,735             $0        $15,103
GANNETT HALL           1          $295         $0         $0        $0         $0             $0           $295
GARAGE                 3       $14,699     $7,239         $0        $0     $8,145             $0        $30,083
GCB                    7       $60,303    $13,502     $2,805        $0     $2,360             $0        $78,969
GEN SERVICES           6       $24,566   $118,967         $0        $0    $43,613             $0       $187,146
GENERAL SITE          18      $239,185   $270,520         $0        $0   $247,422    $29,736,657    $30,493,784
GENTRY HALL            5        $5,167   $131,976         $0        $0     $4,177             $0       $141,320
GEOLOGY                9       $16,695    $22,812         $0        $0     $2,360             $0        $41,868
GOLF CLUB HOUSE        1            $0     $2,740         $0        $0         $0             $0         $2,740
GREENHOUSE 19          1        $2,221         $0         $0        $0         $0             $0         $2,221
GREENHOUSE 20          1        $3,007         $0         $0        $0         $0             $0         $3,007
GREENHOUSE 3           1        $5,204         $0         $0        $0         $0             $0         $5,204
GWYNN                 13       $22,134   $116,923     $9,312    $3,782         $0             $0       $152,151
HEARNES                6      $132,213    $60,217         $0        $0         $0             $0       $192,430
HILL HALL              7       $69,053    $84,427         $0        $0     $2,266             $0       $155,745
INDUSTRIAL EDUC        2            $0    $34,546         $0        $0    $62,353             $0        $96,899
JESSE                 15      $244,356   $434,008     $9,228        $0     $2,360             $0       $689,951
JESSE AUD             10       $32,517    $36,719    $43,850        $0         $0             $0       $113,087
LAB ANIMAL CTR         5       $62,791    $29,960         $0      $996     $8,414             $0       $102,160
LAWS HALL              1        $1,487         $0         $0        $0         $0             $0         $1,487
```

FIGURE 9

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UMC Arts & Science Building
Summary of Maintenance Project Costs

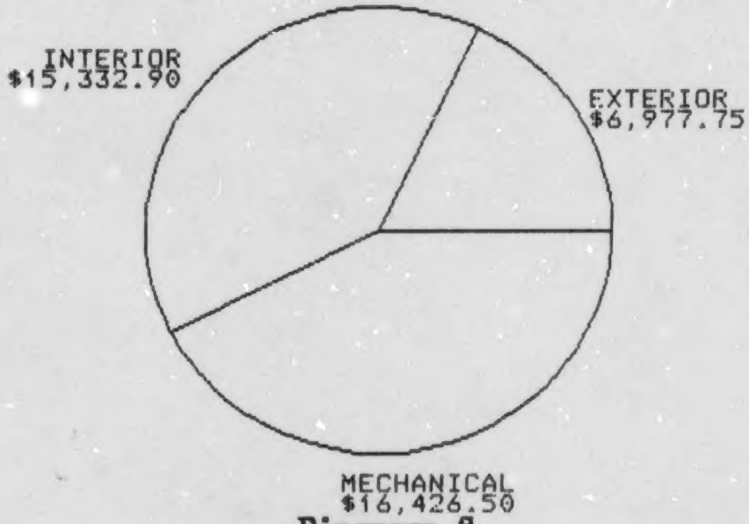
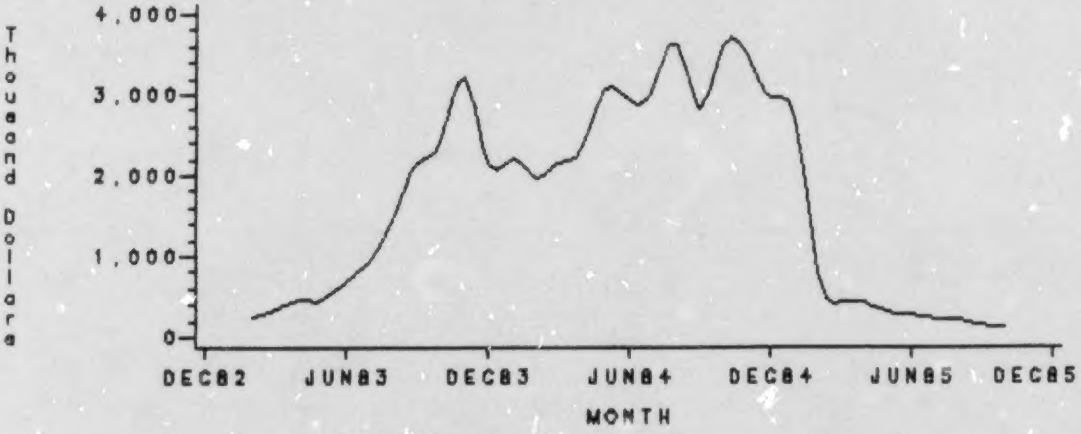


Diagram 3

University of Missouri

State Funded Capital Items
Projected Monthly Expenditures



Total of FY83 Supplemental and
FY84 Governor's Recommendation
Diagram 4

request for cash flow projections. Although by no means exhaustive, these examples illustrate the potential of the automated system.

Physical Plant

Automated systems provide numerous opportunities to streamline record keeping for physical plant operations while providing improved management information. The areas where the potential is greatest are in tracking job orders, scheduling personnel, maintaining materials inventory, accounting and billing. Figure 10 illustrates a set of data entry screens for a job order tracking system. The "New Job Orders/Updates" screen illustrated in Figure 10a permits the entry of new and revised information on work requests. Daily employee and materials information is entered using the screens illustrated in Figures 10b and 10c.

Various reports can be produced from this basic information. A master job order status report lists all active orders, project priority, date scheduled and scheduled completion, project budget, expenditures to date and unused budget (Figure 11). This report is a quick guide to work in progress and readily identifies problem orders.

A work schedule report (Figure 12) serves as a scheduling aid for shop foremen. It shows work to be done during a particular period along with priority of work, and required materials and personnel. The report can be sorted by geographical area of the campus, which assists managers in eliminating duplicate trips. The overall productivity of workers is increased since less time is spent in transit.

A detailed job order transaction report, listing each charge to a project, serves as an itemized statement of charges to the client (Figure 13). Detailed transaction information can be summarized by type of work, by trade, by client and by facility. These summary reports can be used by management to determine which services are in demand in general and by particular client departments. Facility summaries (Figure 14) provide valuable information on the advisability of system replacement or demolition of a facility. These summaries also provide information on the actual life cycle costs experienced with particular systems and particular types of facilities. This improves decision making during the design of new facilities and of replacement components for existing facilities.

Major Construction

In June 1982, the State of Missouri passed a $600,000,000 capital improvements bond issue. The program includes approximately $120,000,000 in new construction at the University of Missouri over a period of three to five years. At the peak of the program, the University may find itself administering $100,000,000 in construction annually, a dramatic expansion from the normal of $30,000,000 annually.

The "boom" resulting from the construction program places unusual demands on the University's construction managers. Maintaining the usual level of quality control while using existing management techniques would require an increase of roughly 30 staff positions, but "staffing up" is not

ENTRY PANEL TEMPLATES

```
                    **NEW WORK ORDER/UPDATES**

Work Order #   =====>                         Labor Hrs.    =====>
Ref. #         =====>                         Scheduled     =====>
Account #1     =====>                         Completed     =====>
Cost #1        =====>
Account #2     =====>
Cost #2        =====>
Account #3     =====>
Cost #3        =====>
Priority       =====>
Bldg. #        =====>
Class          =====>
Type           =====>
```

10a

```
**EMPLOYEE  WORK  REPORT**

  Employee #     =====>
  Work Order     =====>
  Hrs. Reg.      =====>
  Hrs. OT        =====>
  Date           =====>
```

10b

```
**MATERIALS  USE  REPORT**

  Work Order     =====>
  Mat. Type      =====>
  Desc.          =====>
  P.O. #         =====>
  Cost           =====>
```

10c

Figure 10

JOB ORDER STATUS REPORT

JOB ORDER	DESCRIPTION	PRIORITY	SCHEDULED	COMPLETED	ESTIMATE	EXPENDED	BALANCE
				TOTAL			

FIGURE 11

WORK SCHEDULED

FOR WEEK OF:
SHOP:

JOB ORDER	BLDG.	DESCRIPTION	PRIORITY	HRS.EST.	COST EST.	EXP.TO DATE
			TOTAL			

FIGURE 12

WORK ORDER TRANSACTION DETAIL

____________ WORK ORDER: ____________

DATE	LABOR/MAT.	SHOP	MAT. TYPE	COST	TOTAL

TOTAL: $____

FIGURE 13

BUILDING SERVICE REPORT

BUILDING: ____________
(For Year, Month, Week)

JOB ORDER	DESCRIPTION	CLASS	TYPE	COMPLETED	COST

Total Job Orders: ________

Total: ____

FIGURE 14

a desirable option because of the difficulty of attracting quality employees to a temporary position.

Automated construction management techniques developed as a part of FOCIP have assisted the University in dealing with the new construction program by increasing the productivity of current employees, thereby reducing the need for additional positions. The automated systems available with FOCIP fall into three broad categories: accounting, payments and management information (Diagram 5). By tieing specific construction project information together with the existing University financial accounting and accounts payable systems, FOCIP provides managers with up to date financial information while reducing the manual labor involved. Economizing on management and clerical resources means that more of the bond money can be spent for its intended purpose of constructing new facilities.

Management systems (Diagram 6) focus on information the University needs to guarantee construction projects are completed on time (schedule) and within budget (cost). A materials tracking system enables the University to purchase major equipment and facility components directly. In addition to the usual benefits of large scale purchasing, the University can take advantage of exemption from state sales taxes. Although this potential has always existed, it was too administratively burdensome to be cost effective before the development of the automated inventory system. The change order tracking system focuses on the aspect of construction projects which most frequently breaks project budgets, delays schedules and undermines quality control. The system permits University management to maintain a rigorous review process for change order requests. Such a review would probably not be feasible with manual information techniques.

Figures 14 - 17 are examples of the various management reports which the construction management systems of FOCIP can produce. Figure 14 is a master project status report intended to give managers most of the information they need about a project on a single page. Figures 15 and 16 are summary listings used for coordination meetings during the design phase and during the construction phase. Figure 17 is a sample from the weekly change order status report giving detailed information on current project contingency, review status of change order requests and miscellaneous adjustments to project budgets.

In addition to these regular reports, FOCIP produces a broad array of special reports. Figures 18 - 20 are examples of these special analyses. Figure 18 is a graphical projection of management FTE's required during the University construction program. Figure 19 is a summary of workload by coordinator, useful for assigning new projects. Figure 20 is a Gantt chart used by field personnel in tracking construction progress against schedule.

Summary and Conclusions

Fiscal crises at colleges and universities place new demands on facilities managers. New management tools available with current information technology can help to offset the new demands. A comprehensive facilities management system satisfies managers' basic requirements for information on existing facilities, facilities requirements and resources.

Major Construction Applications

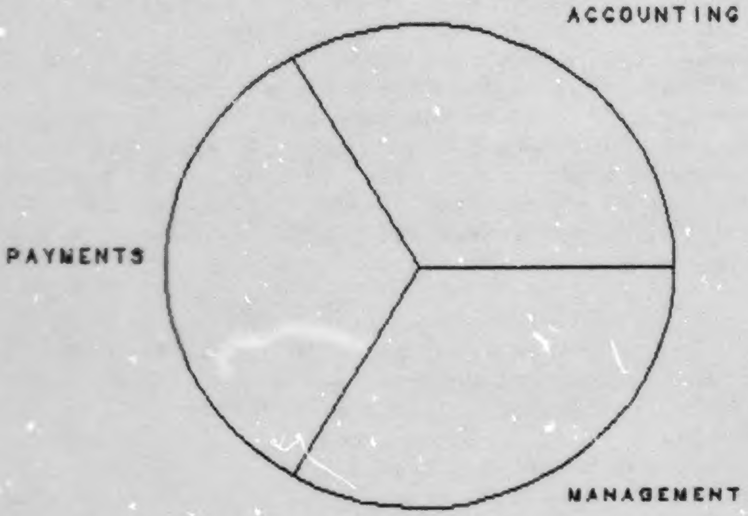

ACCOUNTING
PAYMENTS
MANAGEMENT

Diagram 5

Major Construction
Specific Management Applications

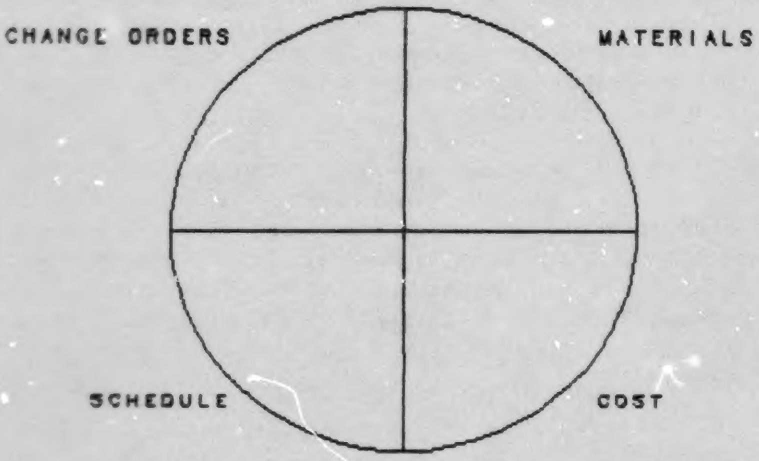
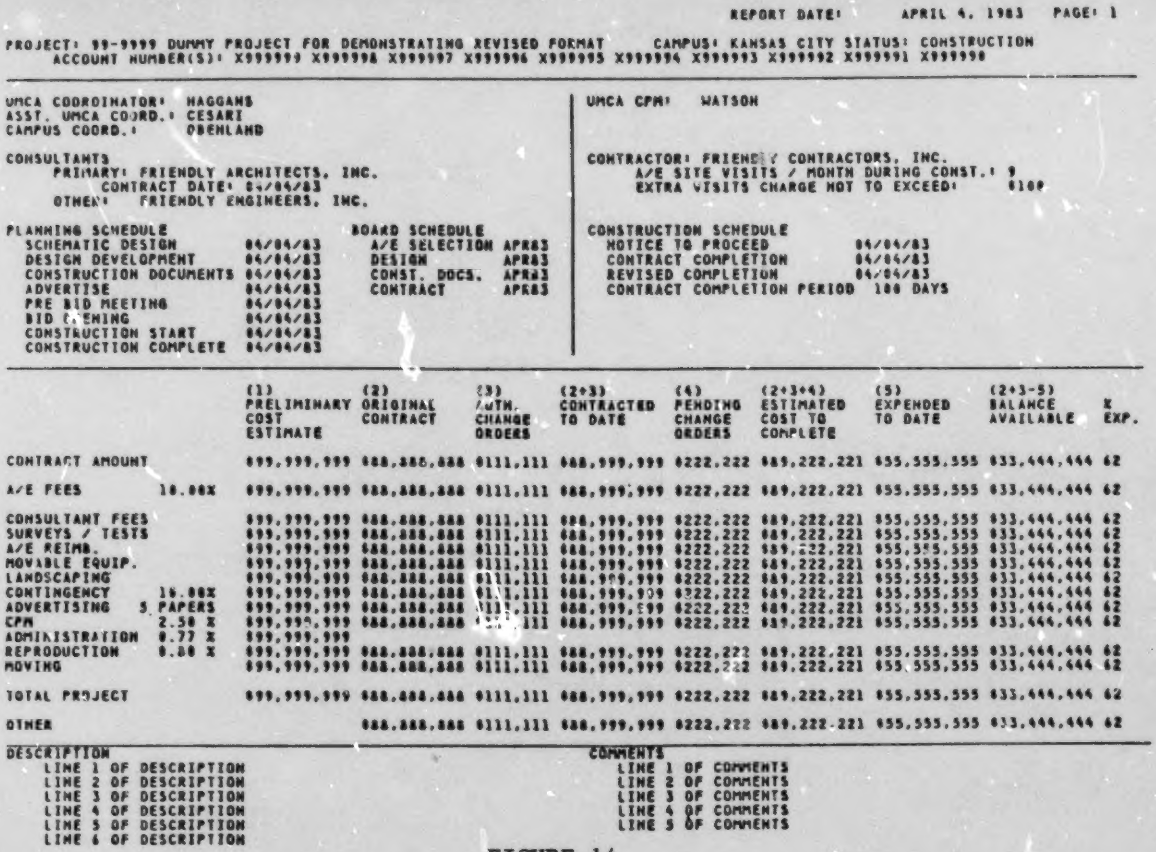

CHANGE ORDERS
MATERIALS
SCHEDULE
COST

Diagram 6



```
                                                                      REPORT DATE:     APRIL 4, 1983   PAGE: 1
PROJECT: 99-9999 DUMMY PROJECT FOR DEMONSTRATING REVISED FORMAT     CAMPUS: KANSAS CITY STATUS: CONSTRUCTION
     ACCOUNT NUMBER(S): X999999 X999998 X999997 X999996 X999995 X999994 X999993 X999992 X999991 X999990
-------------------------------------------------------------------------------------------------------------------
UMCA COORDINATOR:  HAGGANS                                |  UMCA CPM:   WATSON
ASST. UMCA COORD.: CESARI                                 |
CAMPUS COORD.:     OBENLAND                               |
                                                          |
CONSULTANTS                                               |  CONTRACTOR: FRIENDLY CONTRACTORS, INC.
     PRIMARY: FRIENDLY ARCHITECTS, INC.                   |       A/E SITE VISITS / MONTH DURING CONST.: 9
          CONTRACT DATE: 04/04/83                         |       EXTRA VISITS CHARGE NOT TO EXCEED:      $100
     OTHER:   FRIENDLY ENGINEERS, INC.                    |
                                                          |
PLANNING SCHEDULE                     BOARD SCHEDULE      |  CONSTRUCTION SCHEDULE
  SCHEMATIC DESIGN          04/04/83    A/E SELECTION APR83 |   NOTICE TO PROCEED          04/04/83
  DESIGN DEVELOPMENT        04/04/83    DESIGN        APR83 |   CONTRACT COMPLETION        04/04/83
  CONSTRUCTION DOCUMENTS    04/04/83    CONST. DOCS.  APR83 |   REVISED COMPLETION         04/04/83
  ADVERTISE                 04/04/83    CONTRACT      APR83 |   CONTRACT COMPLETION PERIOD  100 DAYS
  PRE BID MEETING           04/04/83                      |
  BID OPENING               04/04/83                      |
  CONSTRUCTION START        04/04/83                      |
  CONSTRUCTION COMPLETE     04/04/83                      |
-------------------------------------------------------------------------------------------------------------------
                         (1)         (2)         (3)      (2+3)       (4)      (2+3+4)     (5)         (2+3-5)
                         PRELIMINARY ORIGINAL    AUTH.    CONTRACTED  PENDING  ESTIMATED   EXPENDED    BALANCE     %
                         COST        CONTRACT    CHANGE   TO DATE     CHANGE   COST TO     TO DATE     AVAILABLE   EXP.
                         ESTIMATE                ORDERS               ORDERS   COMPLETE

CONTRACT AMOUNT          $99,999,999 $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62

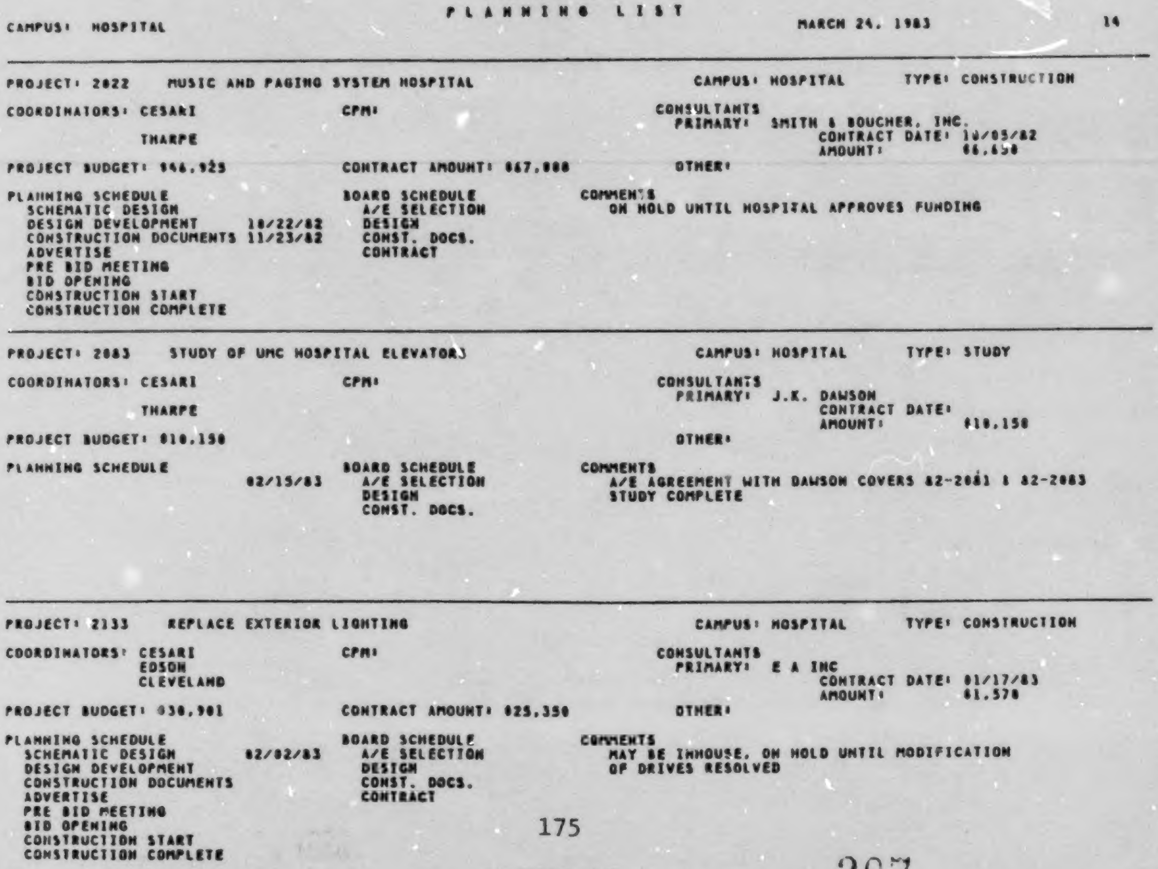
A/E FEES        10.00%   $99,999,999 $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62

CONSULTANT FEES          $99,999,999 $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62
SURVEYS / TESTS          $99,999,999 $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62
A/E REIMB.               $99,999,999 $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62
MOVABLE EQUIP.           $99,999,999 $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62
LANDSCAPING              $99,999,999 $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62
CONTINGENCY     10.00%   $99,999,999 $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62
ADVERTISING   5 PAPERS   $99,999,999 $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62
CPM             2.50 %   $99,999,999 $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62
ADMINISTRATION  0.77 %   $99,999,999
REPRODUCTION    0.80 %   $99,999,999 $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62
MOVING                   $99,999,999 $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62

TOTAL PROJECT            $99,999,999 $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62

OTHER                                $88,888,888 $111,111 $88,999,999 $222,222 $89,222,221 $55,555,555 $33,444,444 62
-------------------------------------------------------------------------------------------------------------------
DESCRIPTION                                                  COMMENTS
    LINE 1 OF DESCRIPTION                                        LINE 1 OF COMMENTS
    LINE 2 OF DESCRIPTION                                        LINE 2 OF COMMENTS
    LINE 3 OF DESCRIPTION                                        LINE 3 OF COMMENTS
    LINE 4 OF DESCRIPTION                                        LINE 4 OF COMMENTS
    LINE 5 OF DESCRIPTION                                        LINE 5 OF COMMENTS
    LINE 6 OF DESCRIPTION
```

FIGURE 14



```
                                  P L A N N I N G   L I S T
CAMPUS:  HOSPITAL                                                  MARCH 24, 1983                    14
-------------------------------------------------------------------------------------------------------------
PROJECT: 2022    MUSIC AND PAGING SYSTEM HOSPITAL                 CAMPUS: HOSPITAL      TYPE: CONSTRUCTION

COORDINATORS: CESARI               CPM:                           CONSULTANTS
                                                                    PRIMARY:  SMITH & BOUCHER, INC.
              THARPE                                                          CONTRACT DATE: 10/05/82
                                                                              AMOUNT:        $6,658
PROJECT BUDGET: $46,925            CONTRACT AMOUNT: $67,000       OTHER:

PLANNING SCHEDULE                  BOARD SCHEDULE             COMMENTS
  SCHEMATIC DESIGN                   A/E SELECTION               ON HOLD UNTIL HOSPITAL APPROVES FUNDING
  DESIGN DEVELOPMENT     10/22/82    DESIGN
  CONSTRUCTION DOCUMENTS 11/23/82    CONST. DOCS.
  ADVERTISE                          CONTRACT
  PRE BID MEETING
  BID OPENING
  CONSTRUCTION START
  CONSTRUCTION COMPLETE
-------------------------------------------------------------------------------------------------------------
PROJECT: 2083    STUDY OF UMC HOSPITAL ELEVATORS                  CAMPUS: HOSPITAL      TYPE: STUDY

COORDINATORS: CESARI               CPM:                           CONSULTANTS
                                                                    PRIMARY:  J.K. DAWSON
              THARPE                                                          CONTRACT DATE:
                                                                              AMOUNT:        $10,150
PROJECT BUDGET: $10,150                                           OTHER:

PLANNING SCHEDULE                  BOARD SCHEDULE             COMMENTS
                         02/15/83    A/E SELECTION               A/E AGREEMENT WITH DAWSON COVERS 82-2081 & 82-2083
                                     DESIGN                      STUDY COMPLETE
                                     CONST. DOCS.


-------------------------------------------------------------------------------------------------------------
PROJECT: 2133    REPLACE EXTERIOR LIGHTING                        CAMPUS: HOSPITAL      TYPE: CONSTRUCTION

COORDINATORS: CESARI               CPM:                           CONSULTANTS
              EDSON                                                 PRIMARY:  E A INC
              CLEVELAND                                                       CONTRACT DATE: 01/17/83
                                                                              AMOUNT:        $1,570
PROJECT BUDGET: $30,901            CONTRACT AMOUNT: $25,350       OTHER:

PLANNING SCHEDULE                  BOARD SCHEDULE             COMMENTS
  SCHEMATIC DESIGN       02/02/83    A/E SELECTION               MAY BE INHOUSE, ON HOLD UNTIL MODIFICATION
  DESIGN DEVELOPMENT                 DESIGN                      OF DRIVES RESOLVED
  CONSTRUCTION DOCUMENTS             CONST. DOCS.
  ADVERTISE                          CONTRACT
  PRE BID MEETING
  BID OPENING
  CONSTRUCTION START
  CONSTRUCTION COMPLETE
```

FIGURE 15

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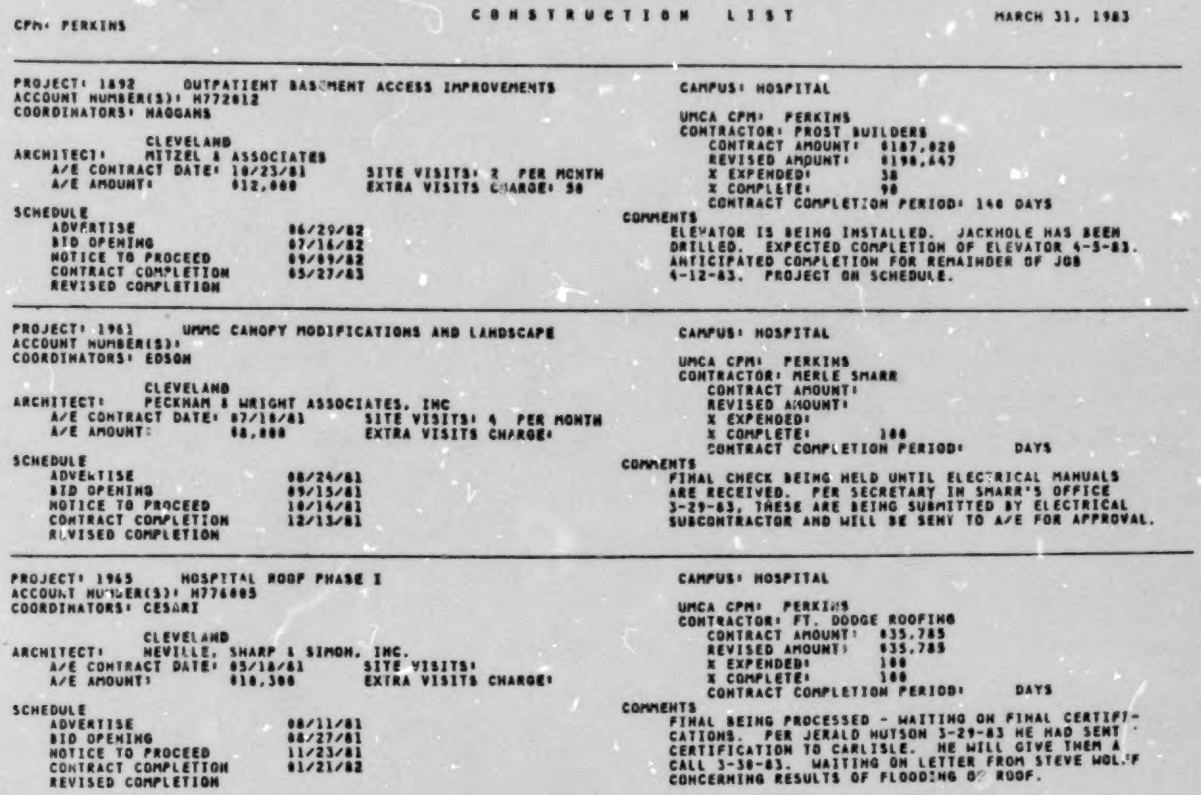
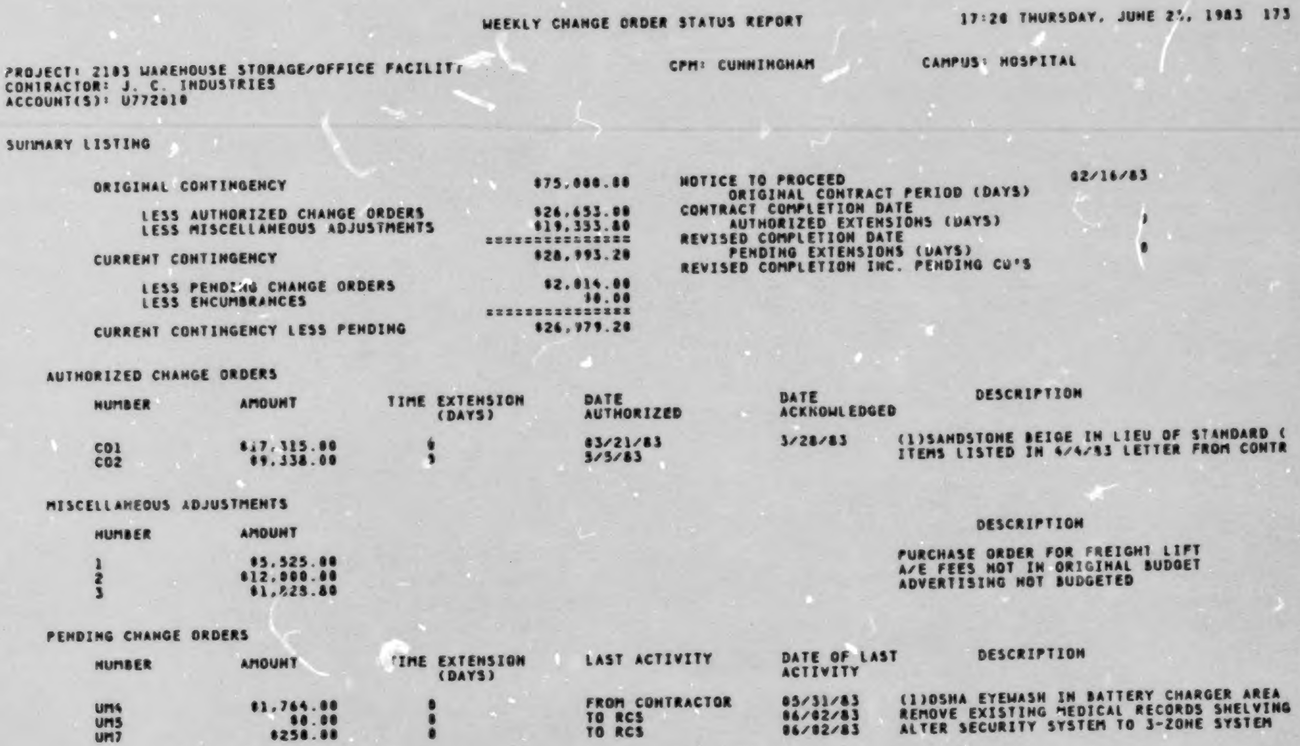


```
CPM: PERKINS                     C O N S T R U C T I O N   L I S T                    MARCH 31, 1983
________________________________________________________________________________________________________
PROJECT: 1892     OUTPATIENT BASEMENT ACCESS IMPROVEMENTS          CAMPUS: HOSPITAL
ACCOUNT NUMBER(S): H772012
COORDINATORS: HAGGANS                                              UMCA CPM:  PERKINS
                                                                   CONTRACTOR: PROST BUILDERS
           CLEVELAND                                                  CONTRACT AMOUNT:  $187,020
ARCHITECT:    MITZEL & ASSOCIATES                                     REVISED AMOUNT:   $190,647
    A/E CONTRACT DATE: 10/23/81       SITE VISITS: 2  PER MONTH       % EXPENDED:       30
    A/E AMOUNT:         $12,000       EXTRA VISITS CHARGE: 50         % COMPLETE:       90
                                                                      CONTRACT COMPLETION PERIOD: 140 DAYS
SCHEDULE                                                       COMMENTS
    ADVERTISE                   06/29/82                           ELEVATOR IS BEING INSTALLED.  JACKHOLE HAS BEEN
    BID OPENING                 07/16/82                           DRILLED.  EXPECTED COMPLETION OF ELEVATOR 4-5-83.
    NOTICE TO PROCEED           09/09/82                           ANTICIPATED COMPLETION FOR REMAINDER OF JOB
    CONTRACT COMPLETION         05/27/83                           4-12-83.  PROJECT ON SCHEDULE.
    REVISED COMPLETION
________________________________________________________________________________________________________
PROJECT: 1961     UMMC CANOPY MODIFICATIONS AND LANDSCAPE          CAMPUS: HOSPITAL
ACCOUNT NUMBER(S):
COORDINATORS: EDSON                                                UMCA CPM:  PERKINS
                                                                   CONTRACTOR: MERLE SMARR
           CLEVELAND                                                  CONTRACT AMOUNT:
ARCHITECT:    PECKHAM & WRIGHT ASSOCIATES, INC                        REVISED AMOUNT:
    A/E CONTRACT DATE: 07/10/81       SITE VISITS: 4  PER MONTH       % EXPENDED:
    A/E AMOUNT:         $8,000        EXTRA VISITS CHARGE:            % COMPLETE:       100
                                                                      CONTRACT COMPLETION PERIOD:     DAYS
SCHEDULE                                                       COMMENTS
    ADVERTISE                   08/24/81                           FINAL CHECK BEING HELD UNTIL ELECTRICAL MANUALS
    BID OPENING                 09/15/81                           ARE RECEIVED.  PER SECRETARY IN SMARR'S OFFICE
    NOTICE TO PROCEED           10/14/81                           3-29-83, THESE ARE BEING SUBMITTED BY ELECTRICAL
    CONTRACT COMPLETION         12/13/81                           SUBCONTRACTOR AND WILL BE SENT TO A/E FOR APPROVAL.
    REVISED COMPLETION
________________________________________________________________________________________________________
PROJECT: 1965     HOSPITAL ROOF PHASE I                            CAMPUS: HOSPITAL
ACCOUNT NUMBER(S): H776005
COORDINATORS: CESARI                                               UMCA CPM:  PERKINS
                                                                   CONTRACTOR: FT. DODGE ROOFING
           CLEVELAND                                                  CONTRACT AMOUNT:  $35,785
ARCHITECT:    NEVILLE, SHARP & SIMON, INC.                            REVISED AMOUNT:   $35,785
    A/E CONTRACT DATE: 05/18/81       SITE VISITS:                    % EXPENDED:       100
    A/E AMOUNT:         $10,300       EXTRA VISITS CHARGE:            % COMPLETE:       100
                                                                      CONTRACT COMPLETION PERIOD:     DAYS
SCHEDULE                                                       COMMENTS
    ADVERTISE                   08/11/81                           FINAL BEING PROCESSED - WAITING ON FINAL CERTIFI-
    BID OPENING                 08/27/81                           CATIONS.  PER JERALD HUTSON 3-29-83 HE HAD SENT
    NOTICE TO PROCEED           11/23/81                           CERTIFICATION TO CARLISLE.  HE WILL GIVE THEM A
    CONTRACT COMPLETION         01/21/82                           CALL 3-30-83.  WAITING ON LETTER FROM STEVE WOLFF
    REVISED COMPLETION                                             CONCERNING RESULTS OF FLOODING OF ROOF.
```

FIGURE 16



```
                                   WEEKLY CHANGE ORDER STATUS REPORT            17:20 THURSDAY, JUNE 2[illegible], 1983  173

PROJECT: 2103 WAREHOUSE STORAGE/OFFICE FACILITY               CPM: CUNNINGHAM         CAMPUS: HOSPITAL
CONTRACTOR: J. C. INDUSTRIES
ACCOUNT(S): U772010

SUMMARY LISTING

     ORIGINAL CONTINGENCY                       $75,000.00   NOTICE TO PROCEED                          02/16/83
                                                                 ORIGINAL CONTRACT PERIOD (DAYS)
          LESS AUTHORIZED CHANGE ORDERS         $26,653.00   CONTRACT COMPLETION DATE
          LESS MISCELLANEOUS ADJUSTMENTS        $19,353.80       AUTHORIZED EXTENSIONS (DAYS)              3
                                           ===============   REVISED COMPLETION DATE
     CURRENT CONTINGENCY                        $28,993.20       PENDING EXTENSIONS (DAYS)                 0
                                                             REVISED COMPLETION INC. PENDING CO'S
          LESS PENDING CHANGE ORDERS             $2,014.00
          LESS ENCUMBRANCES                          $0.00
                                           ===============
     CURRENT CONTINGENCY LESS PENDING           $26,979.20

  AUTHORIZED CHANGE ORDERS

     NUMBER         AMOUNT          TIME EXTENSION     DATE                  DATE               DESCRIPTION
                                        (DAYS)         AUTHORIZED            ACKNOWLEDGED

     CO1            $17,315.00            0            03/21/83              3/28/83      (1)SANDSTONE BEIGE IN LIEU OF STANDARD (
     CO2             $9,338.00            3            5/5/83                             ITEMS LISTED IN 4/4/83 LETTER FROM CONTR

  MISCELLANEOUS ADJUSTMENTS

     NUMBER         AMOUNT                                                                       DESCRIPTION

     1               $5,525.00                                                            PURCHASE ORDER FOR FREIGHT LIFT
     2              $12,000.00                                                            A/E FEES NOT IN ORIGINAL BUDGET
     3               $1,828.80                                                            ADVERTISING NOT BUDGETED

  PENDING CHANGE ORDERS

     NUMBER         AMOUNT          TIME EXTENSION     LAST ACTIVITY         DATE OF LAST       DESCRIPTION
                                        (DAYS)                               ACTIVITY

     UM4             $1,764.00            0            FROM CONTRACTOR       05/31/83     (1)OSHA EYEWASH IN BATTERY CHARGER AREA
     UM5                 $0.00            0            TO RCS                06/02/83     REMOVE EXISTING MEDICAL RECORDS SHELVING
     UM7               $250.00            0            TO RCS                06/02/83     ALTER SECURITY SYSTEM TO 3-ZONE SYSTEM
```

FIGURE 17

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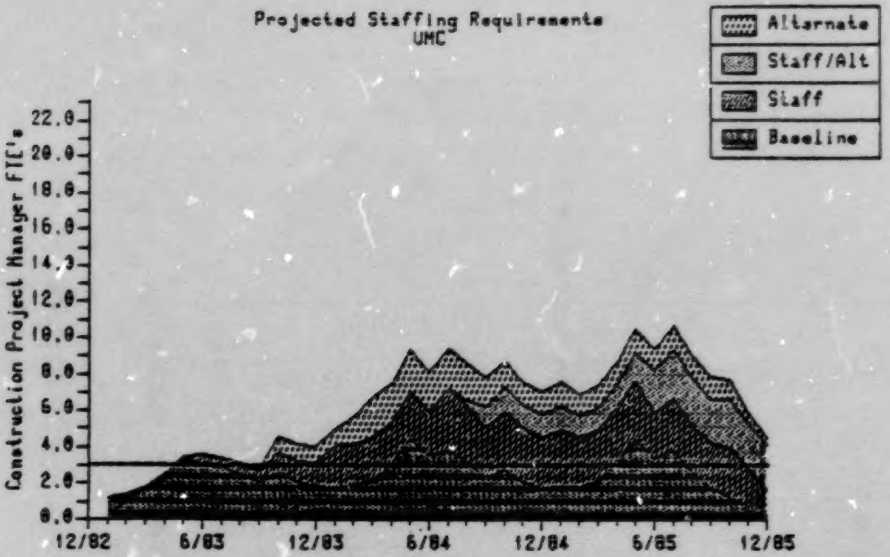

FIGURE 18

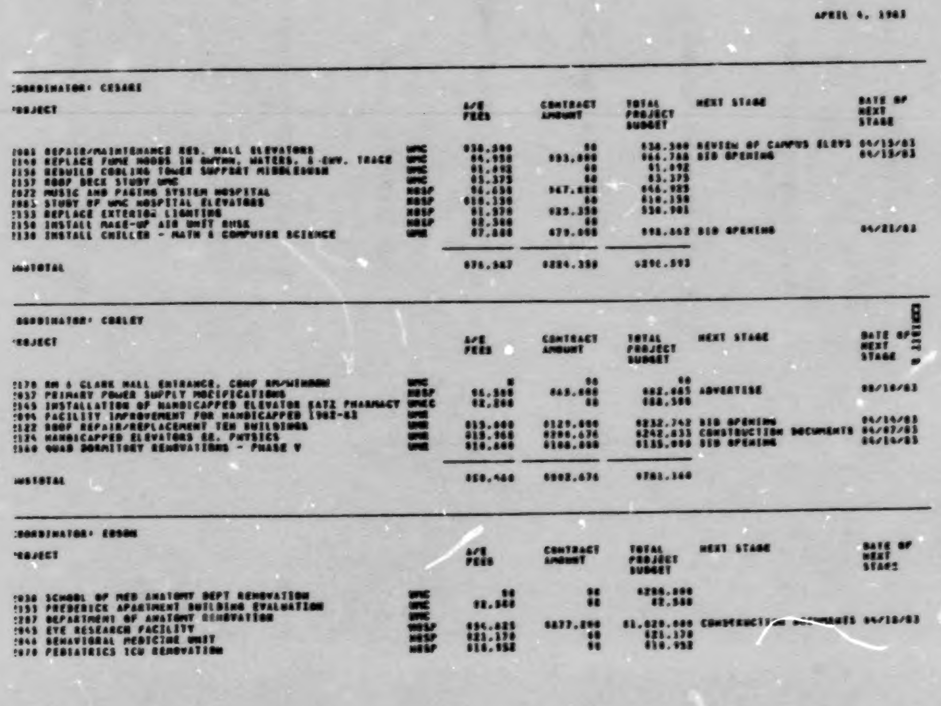

FIGURE 19

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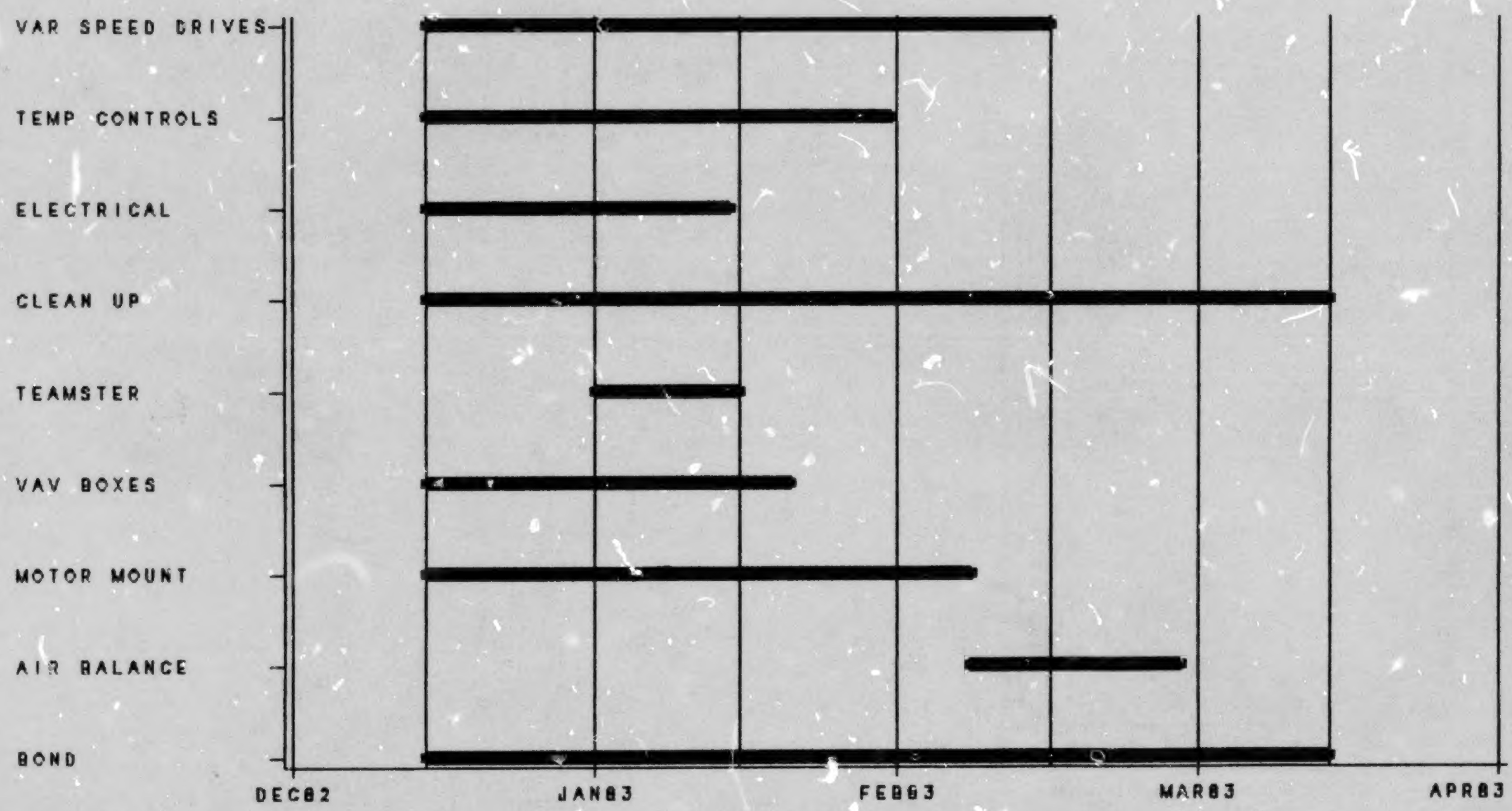


Renovation of HVAC System
Engineering Research Building, UMR

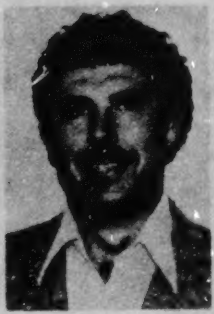
Figure 20

An automated system has the advantage of being readily maintained and readily shared by different users. Automated systems are more effective than manual systems in preparing timely summaries and analyses of basic information which are of primary importance to managers. An automated facilities management system has the added advantage of being able to interface with other automated systems which an institution may have in place, eliminating duplication of effort and fostering consistency.

Because an institution's computing experts are usually faced with their own agenda of backlogged work, facilities managers should consider using their entrepreneurial skills to develop their own systems. Since the best computerized systems are designed by the end user, facilities managers should play a major role in system development even when the computing experts are willing and able to assist.

The University of Missouri experience has led us to the conclusion that the development of a comprehensive facilities management system is both desirable and feasible for most institutions. We have also discovered that the key to the success of such an undertaking is the active involvement of the institution's facilities managers.

Hutson


Parker

Howitt

ADMINISTRATION & INSPECTION OF CONTRACTED CUSTODIAL SERVICES

By Robert Hutson - Manager, Bldg. Operations & Systems, Stanford University

Ron Parker - Contract Administrator, Stanford University

Ralph Howitt - Quality Assurance Inspector, Stanford University

Contracted Services - Their Nature and Management

Custodial services are one of the most visible components of the Physical Plant operation. The "quantity" and "quality" of custodial services are quite evident to building occupants, faculty and students. However, unless these services are properly managed, they often become a controversial if not an emotional issue.

Custodial services may be provided by the Physical Plant personnel (in-house) or by a contractor. The issue of in-house vs. contract performance is often debated as the various advantages and disadvantages inherent with each method. Overall cost and quality are the most frequently cited factors as the basis for determining a method of performance.

While cost is definitive and has a tangible value, the quality of either in-house or contract performance is directly dependent on the management of the services . In the case of contracted services, these management responsibilities extend to both contractor (seller) and the Physical Plant (buyer). The responsibilities of the seller are to provide, schedule, execute and inspect the services. The responsibilities of the buyer are to administer the services and perform the Quality Assurance (QA) function to ensure that the procured services are of the specified quality level. Often problems of poor contract performance are actually due to the lack of contract administration and proper inspection by the buyer.

In order to understand this relationship between contract performance and the administrative and inspection functions, it is necessary to examine the environment under which contract services are provided. Rarely do customer expectations equal contract specifications.

This is also true for both contract and in-house performance. Under contract performance, this gap is often translated as poor contract performance. While this identical condition exists for in-house performance, it is usually addressed through the traditional channels, i.e., worker, supervisor, etc. While expectations may never be met, communication and feedback is constantly available among customer, custodian and management.

Contrary to this is contract performance where a rigid, unresponsive barrier is often perceived, first by the customer and secondly by the Physical Plant. If this mismatch between expectations and contract specifications is simply referred to the contractor as a complaint, the result will be a "knee-jerk" type of reaction. Original cleaning specifications are compromised and services begin to errode. Services also tend to become inequitablely distributed as the contractor rapidly modifies procedures and specifications to accomodate complaints. The results are a degradation of the overall service level. Contractural relations between the contractor and the Physical Plant management deteriorate as the number of complaints becomes the primary indicator of contract performance.

These conditions are symptoms of ineffective contract administration and inspection. First, for not exercising an overall administrative effort and establishing communication channels where customer needs may be addressed. Secondly, for managing by complaint and reaction to spot occurances rather than addressing overall quality levels. As previously stated, while the contractor is responsible for providing and managing the custodial services, it is the responsibility of the buyer to administer and inspect the services.

Contact management must encompass both the administration and inspection functions. While the administrative effort is directed toward the program/planning responsibilities and daily operational matters, the QA effort should be directed toward making an overall assessment of the contractor's performance. Organizationally, these responsibilities or functions are at equivalent levels and enjoy a "dotted line" relationship. However, this relationship must be mutually supportive. The QA effort must address problem areas brought to the Administrator's attention and the Administrator must work with the Contractor to promptly correct defective work identified by the QA Inspector.

Defining the role and operational responsibilities of both the Contract Administrator and QA Inspector provides a basis for establishing the relationships between these functions and the "quantity" and "quality" of contracted services.

Contract Administration - Role and Responsibilities

The role and responsibilities of the Contract Administrator start with the day-to-day needs and extend into the program/planning needs. The day-to-day operation is one of ongoing public relations, quality control and educating the recipients of custodial services as to what services are provided under the custodial contract. The long range or program responsibilities are to present to management on an ongoing basis the program objectives that reflect what services are needed by the Academic Community in order to maintain the physical plant and provide a healthy and esthetically pleasing working environment.

In order to execute these responsibilities effectively, it is necessary to institute and develop four key elements:

- Inventory
- Communication
- Service levels
- Support for Q.A. Program

Inventory -

Due to the sheer quantity of space that is cleaned on the typical campus and the multiple uses of the space, it is essential to have accurate cleaning schedules. These schedules should reflect the contract specifications in terms of cleaning tasks to be performed and frequency of performance. It is also helpful to know the names of the responsible Custodian and Building Managers for each of the areas. An inventory is essential to the Administrator in order to handle the day-to-day operation and to answer questions accurately regarding service levels and performance. The QA Inspector also requires an accurate inventory in order to know where and what to inspect.

Maintaining such an inventory obviously requires a significant amount of recordkeeping. As cleaning requirements constantly change, this data must be easily and accuratly retrievable. Data of this nature lends itself to a computerized system. If established in this manner, additional information such as number of paper dispensers, etc. can also be maintained. A computer based system can also incorporate a financial matrix with inventory adjustments in order that contract cost adjustments are made as inventory changes. A computerized system can also be used to model and generate cleaning schedules.

Communication -

Communication systems must be established to provide a means by which the Academic Community can provide direct feedback to the Contract Administrator and the QA Inspector regarding poor performance of the Custodial Contractor. This communication system should be an active system and not one based on reaction. A good system minimizes complaints by communicating the custodial service levels to the Academic Community. It also provides an avenue for both Administrator and Contractor to take stock of the customers' needs, problems, etc. This ongoing education process with the Academic Community, one that informs them of what they can and cannot expect from the custodial contract, cuts down on the number of misguided complaints and strengthens the Q.A. program. This education program is carried out by means of frequent meetings with the Academic Department Managers. Meetings are also held on a less frequent basis with the Building Supervisor for the Custodial Contractor. This team approach to problem solving promotes more accountability and involvement on the part of the Contractor Supervisor. These meetings also allow for providing updated cleaning schedules and proposed changes in service.

In addition to communication with the Academic community, an ongoing communication system with the Custodial Contractor is essential. However, for an effective communication system to develop, there must be good rapport and trust between the Contractor and Administrator. When a department is not fair in its criticism of the Contractor, the Contract Administrator must be prepared to support the Contractor. Frequent meetings (preferably daily) keep communication channels open and provide the Contractor with input from the Q.A. Program. This allows for ongoing "fine tuning" of the system and for the correction of unacceptable performance by Contractor personnel before an awareness of defective service or complaints develop from the Academic departments.

Service Levels -

The cleaning task performed and frequency of performance establishes the custodial service level. Cleaning needs should be identified and service levels established for each individual space considering the type and use of the space. As both the use and intensity of space use change frequently, service levels must also be adjusted to reflect these frequent space changes.

The Custodial service levels or the adjustment of service levels is directly proportional to available funding. As funding is often limited, the Administrator is constantly faced with previously cited conditions where "expectations" exceed contract specifications or fundable service levels. The proper allocation of available funds is best determined with the Building Managers through the communication channels previously outlined and through periodic surveys so that some priorization can occur. This method of building a consensus is important to cultivating a cooperative understanding and acceptance of service levels. At times when budget cuts may be necessary, this priorization will also give an indication of what services may be decreased with the least overall impact on the University. Provisions for additive services should be stated in the contract so that individual departments can request and purchase additional custodial services beyond those provided by the University.

Support For Q.A. Program -

Last but not least is the importance of mutual support and ongoing communication between the Q.A. Inspector and the Contract Administrator. The Administrator must be knowledgeable of any deficiencies in performance on the part of the Custodial Contractor in order for corrective action to be undertaken. On the other hand, the Q.A. Inspector needs to know of any complaints, problems that the Administrator is aware of through his sources, so that a physical inspection and evaluation relative to contract guidelines can occur.

Quality Assurance - Role and Responsibilities

The Quality Assurance Inspector has two primary responsibilities: to evaluate the effectiveness of the custodial program and to ensure that the work performed is in conformance with contract provisions.

The custodial contract should include a formal Quality Control Program as a contract requirement. This places the formal responsibility on the contractor to ensure that work is completed according to the contract specifications. However, it is the responsibility of the buyer to inspect the work in order to evaluate the quality of services being rendered.

Frequently, the lack of an administration/inspection effort allows the contractor to compromise the contractural requirements and the buyer receives less than acceptable service. As a result of this lack of attention, the buyer fails to receive the full value of services purchased. A well executed QA plan will prevent this condition from developing.

Evaluating the "effectiveness" of the custodial program is to determine how well the contract specifications satisfy the customer's needs. While cleaning schedules are tailored in accord with the type of area being serviced, there are variances in the cleaning requirements for similar areas. The QA Inspector should be attuned to this fact and identify areas which are being under or over cleaned in relation to the use of the space. Observations of this nature should be closely correlated with past inspection reports, complaints and contacts with building managers and occupants. The QA Inspector should provide this feedback to the Contract Administrator for possible adjustment in cleaning schedules.

The other major role and responsibility of the QA Inspector is to determine the adequacy of the contractor's performance. Only by inspections and documentation can the true performance of the contractor be substantiated. The Inspector must detect, record and report any deviations from the contract requirements. When minor deviations are detected, they should be reported directly to the contractor's site manager for corrective action. Major deviations which involve adjustments in contract price should be reported to the Contract Administrator.

Several methods of inspection are utilized to carry out a QA program. The primary method used by Stanford for assessing the contractor's overall level of performance is by Random Sampling. Stanford has about one hundred and fifty buildings serviced under the custodial contract. These buildings vary in size and cover the whole range of university activities including offices, classrooms, lecture halls, auditoriums, libraries, lounges, eating areas, restrooms, stairways, elevators, corridors, etc. Obviously, only a small portion of these buildings can be inspected on any one day, but by random selection. A significant number of buildings will be inspected and an overall level of performance will be observed. With this type of inspection, the contractor is unable to second guess the areas to be evaluated at a given time.

A second evaluation method is by Planned Sampling. Here, the sample selection is based on some subjective rationale, usually arbitrarily determined. QA plans, based on planned sampling, are useful when the contractor's performance at selected locations is poor. After discussing this with the contractor's site manager, the contractor will know that work performed at these selected locations is more likely to be monitored than work at other locations. However, the inspector is able to direct his efforts to those areas where he feels they are most needed. Planned sampling does not give an objective view of the contractor's overall level of performance but does provide a systematic way of taking a subjective (biased) look at what the contractor can do.

Evaluation by Validated Complaints is another QA method based on customer awareness. Customers familiar with contract requirements monitor the services provided by the contractor and notify the Contract Administrator or QA Inspector of poor or non-performance of work. Upon notification, the Administrator or Inspector investigates the report and if found to be valid, documents the complaint. Here the building manager is an important link between the contractor's performance and the Contract Administrator/QA Inspector. The building manager, rather than just anyone in the building, should serve as the funnel for channeling valid complaints. It is much easier to resolve complaints for a specific facility if a single point of contact is established. A good working relationship with individual building managers and educating them on the service level for their facility will pay big dividends.

Now, how does the QA Inspector actually operate? The first step is to develop an inspection schedule. Ideally the custodial contract should be structured so that the contractor must provide an overall annual plan and detailed monthly, weekly and daily work schedules. For example, restrooms and lounges are cleaned daily, classrooms three times a week, offices twice a week; some mopping is done once a week, waxing and buffing quarterly, and stripping, waxing and buffing semi-annually. Only by knowing the contractor's specific schedule of performance in terms of days and hours can the Inspector make a reasonable determination if specified services are being provided. Since randomly generated inspections will not necessarily coincide with the contractor's performance, it is important for the Inspector to know when services were last provided in order that a fair evaluation can be made.

For planned inspections, the Inspector knows when the work is to be performed and when work should be ready for inspection. The schedule of performance should be in complete agreement with the contract specifications.

The "Custodial Inspection Schedule" (Exhibit "A") is prepared two weeks in advance. It will be comprised mostly of buildings selected through the Random Sampling process but supplemented with both Planned Sampling and areas which have had Validated Complaints. This schedule will become a permanent record of the weekly performance of inspections since it includes the Building Number, Building Name, Method of Selection, Date Inspected and any pertinent comments.

With the schedule established, the Inspector performs the inspections which are recorded on "The Inspection Report" (Exhibit "B"). The Inspection Report is obviously the main source of documentation. It must answer who, what, when, where, why, how, and any other questions that may arise concerning whether the contract requirements were met. It is a simple statement of facts based on direct observation and becomes a permanent record.

The Custodial Inspection Report format was developed by identifying the performance specifications as indicated in the contract. A listing was made which includes these contractural requirements along with items frequently neglected and sensitive areas which cause repeated customer complaints. These lists were revised and eventually finalized to include twenty items with space for additions in special conditions.

In evaluating the contractor's performance, the Inspector should focus on the overall quality of the work and not "nit-pick" isolated items. He must determine if the work is "substantially completed". In many cases this will be a subjective evaluation. For example, is the floor buffed to a high enough luster? Are all spaces within a room well cleaned except for one corner under a table? The Inspector will encounter numerous evaluations every day and needs to be fair and consistent in judging conditions.

Although overall performance may be highly satisfactory, little annoying problems should be dealt with promptly. Professors like clean chalkboards, clean erasers and a supply of chalk; secretaries want their baskets returned to the same spot after being emptied; no one likes an empty soap dispenser. These "little" items should be noted and brought to the attention of the custodians through the site manager and should be corrected. However, they must be weighed against overall performance before making a final judgement.

As in the Administrator's role, communication is also a key ingredient for the Inspector. A strong line of communication should be established between the occupant, Administrator and Inspector; and between the Administrator and the Contractor.

Recognizing the necessity of the administrative and inspection functions is the first step toward receiving quality contractural services. Incorporating these functions into the Physical Plant Organization and establishing an interactive process between building occupants, Inspectors, Administrator and Contractor will ensure that purchased services are received and occupant needs are met.

EXHIBIT A

CUSTODIAL QA INSPECTION SCHEDULE

Week of ______________________

Bldg. No.	Bldg. Name	*Selection	Date Inspected	Comments

* Selection:

1. Random
2. High Risk
3. Emergency (Requested)
4. Planned

RH:rg
7/16/82

EXHIBIT B

CUSTODIAL INSPECTION REPORT

Building Number ______________
Building Name ______________
Date of Inspection ______________
Outcome of Inspection ______________
Inspector ______________
Scheduled Cleaning Date ______________

16-20 Good
11-15 Needs Work
0-10 Unsatisfactory

		Location
1.	Foreign objects (such as paper) on the floors or stairs	
2.	Old liners in trash cans or overflowing trash cans	
3.	Dirty interior walls	
4.	Dirty interior windows	
5.	Dirty interior doors	
6.	Dirty exterior doors	
7.	Dirty chalkboard	
8.	Chalkboards not clean	
9.	Dusty vent wells	
10.	Trash on the outside paved areas	
11.	Water closets not clean	
12.	Urinals not clean	
13.	Foul odors	
14.	Soap dispenser not functioning	
15.	Paper not properly stocked in restrooms	
16.	Dust on lounge furniture	
17.	Excessive dust around objects on the floor	
18.	Spots on the carpet	
19.	Dirty sinks	
20.	Non-functioning tampon dispensers	
21.	Other	

Comments ____

RH:rg
7/16/82

Dealing With The Entrenched Marginal Performer: An Application of Action Oriented Evaluation

By John T. Gutman
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The proposed paper introduces "Action Oriented Evaluation" (AOE), a process which seeks to provide a just but firm method of managing individuals who are consistently mediocre performers. The paper sets forth and explains a step-by-step evaluation process which utilizes a goal setting technique to improve performance. Failure to meet reasonable performance goals establishes detailed documentation which provides clearly defensible grounds for dismissal while satisfying due process and just cause requirements. Success in meeting well structured performance goals transforms the marginal performer into a productive employee.

An increasingly significant number of individuals in today's organizations have found the limbo which exists between acceptable and unacceptable performance. These "artful dodgers" are familiar to all of us. It appears they somehow intuitively sense the lower limits of acceptable performance and then effortlessly balance themselves on the threshold of disciplinary action. The truly amazing thing is that they are able to do this year after year!

The cumulative effect of this kind of performance is manifested in decreased productivity and poor quality of workmanship. Also lowers the morale and motivation of co-workers. Marginal performers at all levels of the organization create a form of overhead cost which increases the price of the organization's product or service. Ultimately, this problem results in a form of "cost-push" inflation.

There was a time when marginal performers would "get by" in an organization for a period of years and then, without warning, receive a Friday afternoon pink slip. Legal action and the judicial systems concern for "due process" and "just cause" have caused some organizations to retreat to the other extreme. This is, to do nothing!

DEALING WITH THE PROBLEM:

There is an approach to dealing with the problem which lies between the one extreme of impulsively firing people and the other extreme of doing nothing. Action Oriented Evaluation (AOE) seeks as its prime goal, to improve employee performance through a goal setting process while at the same time recognizing the need to establish a process by which "just cause" for dismissal can be demonstrated and documented. Action Oriented Evaluation recognizes the desirability of retaining employees and improving performance. Frequently, an employee will perform poorly in some aspects of his job while excelling in others. However, the combined result remains unacceptable. Clearly the most frustrating dilemma is the employee who extends the minimal effort necessary to keep from being discharged. Simply and bluntly stated, AOE is a "fork-in-the-road" method by which employees improve over a reasonable period of time or they are removed from the position.

Step I - Identification Of Areas Which Need Improvement

A comprehensive evaluation process should lead to the identification of areas in which an individual needs to improve. Some organizations are unable to clearly identify these areas while others express what change needs to take place but fall short of establishing a specific plan by which change will occur. Good organizational health requires that jobs be properly evaluated and poor performance highlighted and addressed.

Step II - Set Change Goals

Once management has established those areas which need improvement, it is imperative that the manager and the employee mutually recognize the areas of concern. The employee will not be receptive to change unless he or she recognizes the problem and sees the need for change. Assuming there is more than one area of performance which must be improved, the employee and supervisor should establish and agree upon reasonable and attainable goals and priorities. The key to the entire process is the establishment of specific measurable objectives which, when completely attained, will alleviate the performance problem. Depending on the situation, these objectives may be expressed in behavorial terms; that is, a statement of the specific behaviors which are required to bring about the attainment of the change goals or the objectives may be stated in terms of outcomes; that is, the end result desired. The approach used will vary with the individual, their position in the organization and the degree of autonomy under which they operate. A specific time frame should be established for the attainment of the desired goals. The consequences, resulting from failure to attain the stated goals should also be made clear. If this is the first time a particular problem has surfaced, it is conceivable that the consequences of failure may not be discussed specifically. However, if this is the third evaluation in which a centrally important performance goal has not been attained, a specific written statement of the consequences for failure should be set forth. For example: "This is the third evaluation in which your performance in this area has been unsatisfactory. Failure to attain the stated goals will result in the company being unable to continue your employment."

Step III - Ongoing Feedback

Between the setting of goals and the next formal evaluation, the supervisor must provide ongoing feedback to the employee. Where appropriate, examples of desired or undesired behavior should be brought to the attention of the employee and noted in a performance log. It is important for employees to receive positive reinforcement when they are demonstrating behavior which is consistent with the change goal. It is equally important to document incidents of behavior which are not consistent with the desired change or demonstrate other negative aspects of the employee's performance. This documentation, in the form of memos or notes to the employee kept in the personnel file will provide specific examples to substantiate future evaluations and justify possible discharge.

Step IV - Reevaluate In Terms Of Specified Change Objectives

Each specified change objective is then revisited at the time of reevaluation. If the objectives were expressed clearly and in measurable terms, the employee and supervisor should be able to reach reasonable agreement as to whether or not the stated objectives were accomplished. The reevaluation phase leads to one of three possible outcomes:

1. The objectives were clearly accomplished resulting in the desired change in the original state of affairs. If the change was behavioral in nature, the change should be reinforced so that the individual will internalize the change so that the new behavior becomes permanent.

2. The specified objectives were partially accomplished in which case, the evaluator reverts back to Step I and identifies additional areas which need improvement. Steps II, III and IV are then followed until the employee fully attains the stated objectives or clearly fails to make any progress.

3. The employee completely failed to attain any of the desired significant goals. In this case, the employee and the organization are clearly at a crisis point. Three possibilities should be carefully considered:

    a. Good communication did not take place and the process failed.

    b. This is the first time the employee was made aware of the problem and a second chance to improve is warranted.

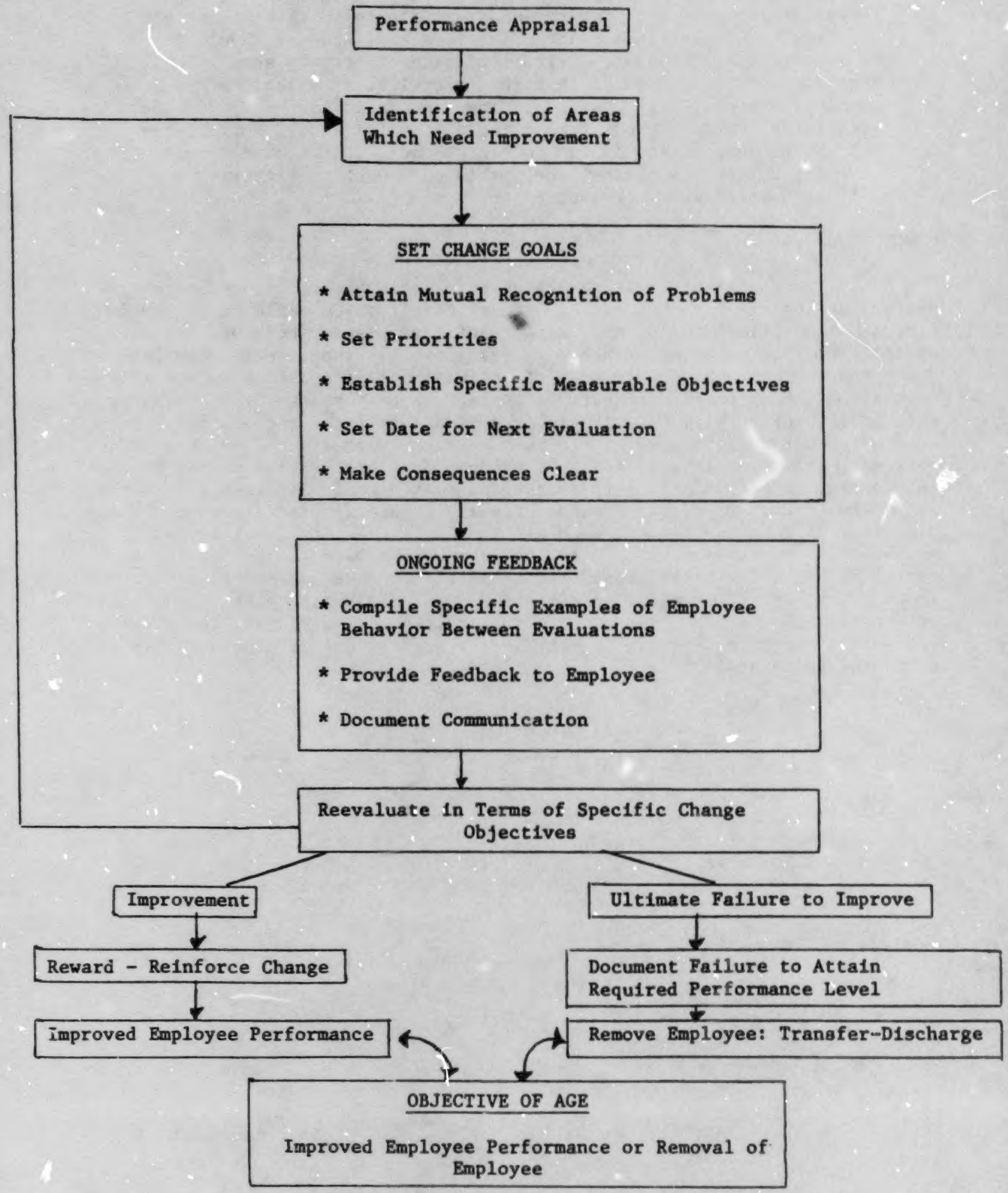
    c. The employee has failed to attain these goals repeatedly in the past and is either unwilling or incapable of success. At this point, the employee would be transferred to a less exacting position or one that better matches skills or dismissed depending on the employee's abilities and attitude as well as the company's circumstances.

This process provides a means by which marginal performers can be required to bring their performance to acceptable levels or face a clearly stated set of consequences for failure to do so. The chances for actually attaining improved performance are enhanced by the mutual goal-setting process. Employees are involved in the indentification of the problems and participate in the setting of objectives to solve them. The objectives that are set should be reasonable and attainable. Finally, these objectives should be specific and measurable so that the supervisor's evaluation can remain as objective as possible. The success of the system depends greatly on the employee's perception of its fairness. While it is not the purpose of the system to "fire people", it does recognize that discharge is sometimes inevitable and seeks to establish a well-documented case for just cause.

CONCLUSION

The appeal of applying Action Oriented Evaluation to cases of repeated marginal performance lies in its simplicity; the employee either improves or is replaced. The determinants of performance, however, are not simplistic. The expectancy theory as developed by Vroom, Porter and Lawler describes performance as a product of motivation level, abilities and role perception. When setting objectives to improve performance, the evaluator will have to be sensitive to the role that each of these factors plays in the employee's performance. It is possible that what appears to be poor personal motivation may, in fact, be a product of frustration caused by poor job design. A person's failure to achieve stated goals may result from their inability to perform certain tasks. Clearly, there are implications of poor placement or poor training in such a situation. Like any other technique, Action Oriented Evaluation is a tool which must be used in conjunction with the manager's overall knowledge of organization and management theory. Used in this way, it will provide an effective means of dealing with the entrenched or persistently marginal performer. The process will also help to identify and correct certain negative aspects in the performance in otherwise highly motivated individuals.

ACTION ORIENTED EVALUATION


Performance Appraisal
Identification of Areas Which Need Improvement
SET CHANGE GOALS
* Attain Mutual Recognition of Problems
* Set Priorities
* Establish Specific Measurable Objectives
* Set Date for Next Evaluation
* Make Consequences Clear
ONGOING FEEDBACK
* Compile Specific Examples of Employee Behavior Between Evaluations
* Provide Feedback to Employee
* Document Communication
Reevaluate in Terms of Specific Change Objectives
Improvement
Ultimate Failure to Improve
Reward - Reinforce Change
Document Failure to Attain Required Performance Level
Improved Employee Performance
Remove Employee: Transfer-Discharge
OBJECTIVE OF AGE
Improved Employee Performance or Removal of Employee

Suggested Additional Readings

1. G. F. Truell, "Ten Steps To Effective Supervision" Supervisory Management, October, 1973 PP 29-35
2. W. J. Kearney, "Behaviorally Anchored Rating Scales, MBO's Missing Ingredient" Personnel Journal, January, 1979 PP 20-25
3. J. B. McMaster, "Designing An Appraisal System That Is Fair And Accurate" Personnel Journal, January, 1979 PP 38-40
4. T. D. Cochran, "Watch Your Step When You Decide To Fire Someone" Supervisory Management, Summer, 1974 PP 2-5
5. T. J. Sielaff, "Modification Of Work Behavior" Personnel Journal, July, 1974 PP 513-517
6. R. H Schaffer, "Demand Better Results And Get Them" Harvard Business Review, November, 1974 PP 91-98
7. H. J. Lasher, "Employee Performance Syndrome: Is Improvement Possible?" Personnel Journal, December, 1974 PP 897-901
8. M. Beer and R. Reek, "Employee Growth Through Performance Management" Harvard Business Review, July, 1976 PP 59-66
9. C. D. Lein, "Preventive Measures Against Marginal Performance" Supervisory Management, May, 1973 PP 2-7
10. L. Schlesinger, "Performance Improvement: The Missing Component Of Appraisal Systems" Personnel Journal, June, 1976 PP 274-275

New Coal Fired Central Energy Plant For the University of Wyoming

By Frank H. Bridgers
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Author's Note

This paper was originally to be co-authored with Mr. Robert Arnold, Physical Plant Director of the University of Wyoming. Unfortunately, Robert Arnold unexpectedly passed away on April 9, 1983. Since the paper had been accepted by the APPA Program Committee, I felt that Bob Arnold would have wanted me to continue with the writing of the paper and the presentation at this annual meeting in Louisville. The person most responsible for the obtaining of funds for the study, for supporting the recommendations of the study, and finally the catalyst for having the University obtain the appropriation from the State Legislature to finance the plant was Mr. Robert Arnold, Physical Plant Director of the University of Wyoming. Without his continuous interest and encouragement, there is considerable doubt if the plant would have been constructed. Therefore, this note is to primarily pay tribute to Bob Arnold for his significant contributions toward bringing about the process to make possible the study, design and construction of this plant over a 7-year period.

Introduction

The new 180,000 pounds per hour coal fired energy plant with three 60,000 pounds per hour boilers for the University of Wyoming is designed to burn natural gas and oil in addition to coal. The final permit from the State of Wyoming Department of Environmental Quality Control to burn coal was given in May, 1983. The plant was essentially finished and put on line in July, 1982 after being dedicated in April of 1982. The project was bid in February, 1980 after the design had been completed in January of 1980. The design contract with the consulting engineers was entered into in April of 1979. In summary, from the time that the design contract was entered into with the University, there was a period of four years required for design, pre-purchasing, applications and approval by the State of Wyoming Department of Environmental Quality, construction, testing, and final acceptance. It is felt that the four year period for this entire process is far below the norm for a coal fired boiler plant to serve a state institution of higher learning.

Procedure

The entire procedure for selecting an engineering firm to make an initial study to recommend the plant capacity, fuels to be utilized; selection of an engineering firm for final design of the recommended facility; the pre-purchase of equipment by the University; the application and approval of the air pollution control by State Agencies; the final design; the bidding of the plant by general contractors; the construction of the plant; the testing of the plant; and final acceptance should be of interest to Physical Plant Directors who contemplate such a project.

In early 1976, the President of the University of Wyoming appointed a Power Plant Utility Distribution Committee, consisting of six members of the University faculty and administrative staff. After inviting a number of engineering firms to submit their qualifications and express an interest in being selected to provide an energy study for a new central energy plant for the University, five firms were selected to appear before the committee for three hour interviews to provide additional evidence of their qualifications and experience to make the energy study. Bridgers and Paxton was selected to make the study which was funded by the State of Wyoming Legislature. The study was entitled "Energy and Utility System Study for the University of Wyoming" and was completed in August of 1977. The study was approved by the University Power Plant Committee and was the basis of the appropriation from the State Legislature to fund the new coal fired central energy plant for the University. Funding by the State Legislature for A-E fees did not take place until 1979 at which time another selection process was accomplished involving the Board of Trustees of the University of Wyoming to select a firm to make the final design. Bridgers and Paxton was selected to provide the final design of the recommended new coal fired central plant.

The first task was to prepare preliminary pre-purchase specifications for the boiler, stokers, emission control equipment, forced draft and induced draft fans and the boiler stacks. This package of equipment was bid by boiler manufacturers with subcontractors for the forced draft and induced draft fans, stokers, combustion controls, the emission control equipment, and boiler stack. Separation of this work from the general construction project was necessary because the boiler dimensions vary significantly with various bidders which affects the structural design of the building.

The decision to have a single responsibility for the entire combustion cycle and the emission controls proved to be very important since all of the components in the combustion and pollution control have to be very closely integrated and coordinated to meet high standards of pollution control required by the State of Wyoming.

The next step was to complete an application for the Department of Environmental Quality and to obtain approval to proceed with the construction of the plant. This application was approved soon after bids had been received for the pre-purchased bid package in September, 1979.

It was necessary to prepare construction drawings for the remainder of the project, which included the building, the boiler feedwater treatment and deaerating heater, the plant piping, the coal storage and automatic handling system, the ash storage and handling system, the structural work to support the boiler, to accommodate the requirements of the forced and induced draft fans, and the breeching and emission control equipment (baghouse). Also included in the general construction drawings were the utilities distribution system to tie in the steam and chilled water mains from the new central plant location to the existing campus distribution system and a new electrical distribution system for the entire campus. It was necessary that construction documents be completed by January, 1980 in order to receive bids in February before the State Legislature adjourned to obtain a final appropriation from the Legislature to cover the financing of the entire project. Pre-purchased equipment for the boilers, stokers, forced and induced draft fans, breeching, emission control equipment, and stacks were $3,780,000. Also pre-purchased were some water chillers for a central campus chilled water system, a cooling tower, and a deaerating heater.

The low bid for the general construction contract, received in late February of 1980 was $12,748,000. This amount with the pre-purchased equipment bid slightly under Four Million Dollars, made a total bid cost of $16,744,424, which was less than five percent over the amount estimated in the 1977 study, even though there was one year lost (1978) due to a legislative moratorium on funding for new facilities at the University. A construction contract was awarded in April, 1980. The plant was essentially complete and dedicated in April, 1982. However, it was not until May, 1983 that all of the tests required for the Department of Environmental Quality were complete and a permit given to operate the plant as a coal fired boiler plant with maximum capacity of 120,000 pounds per hour (one 60,000 pound per hour boiler is designated as a standby in the event of down time for either of the other two boilers for maintenance and repairs). The delay in completing the tests was caused by problems in the combustion controls and the baghouse. The clamps furnished to clamp the bags to the entering tube manifold were not adequate and had to be replaced. The microprocessor based control system had some start-up problems caused by some draft sensors not properly located and other minor difficulties which delayed the final testing. The fact that there was a single responsibility by the boiler manufacturer for the entire air cycle in combustion process and to coordinate the combustion controls, stoker, forced and induced draft fans, and baghouse, was valuable in obtaining the final solution to the problems and successfully testing the system to obtain the permit from the Department of Environmental Quality.

Justification for the Use of Coal as a Primary Energy Source

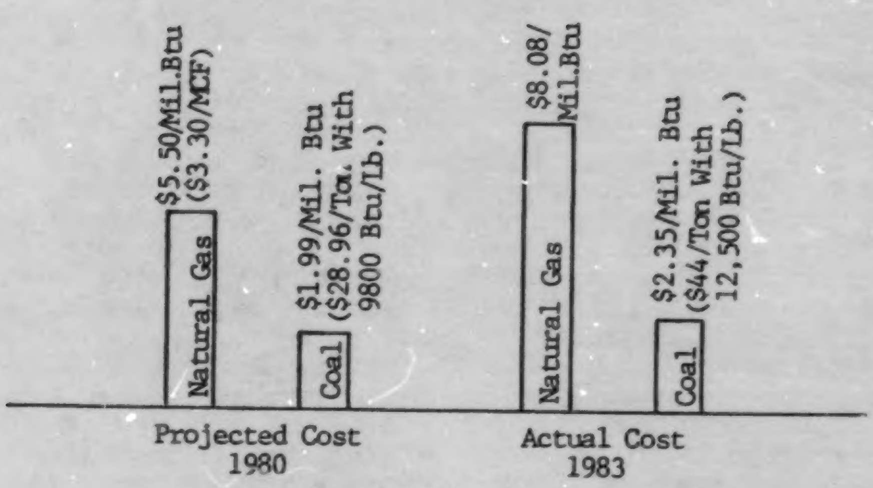
The main reason it was possible to justify the use of coal as the primary source over the use of natural gas, which had been the primary fuel for many years at the University of Wyoming Central Heating Plant, was the rapid escalation of the price of natural gas. The price of natural gas went from $0.22 per MCF (Thousand Cubic Feet) in 1969 to $0.88 per MCF in October of 1976 and rapidly increased to $1.40 per MCF by the end of 1977. For the time period it would take for the plant to be constructed and put on the line, it was estimated that the cost of natural gas would be $3.30 per MCF. At the time of the engineering study in 1977, quotations were received for coal at $22.00 per ton of low Btu coal (9,800 Btu per pound with a sulfur content of less than one percent). It was estimated that by the time the plant could be built that the cost of coal would increase to $29.38 per ton. It was assumed that coal costs would increase five percent per year after the first year of operation from $29.38 per ton On the basis of 9,800 Btus per pound, the initial year of operation gave coal a cost per million Btu of $1.99. The cost per million Btus for natural gas based on 800 Btu per cubic feet (metered at 7,200 feet elevation) was computed at $5.50 per million Btu. It was assumed that natural gas would escalate at a rate of 10% per year. In both cases, it was assumed that the combustion efficiency was 75 percent. Assuming a premium operation and maintenance cost of $233,000 or approximately 25 percent over the operation and maintenance costs for a gas fired plant, a payback period was calculated to be 6.9 years. This payback period did not include interest costs on the capital investment of $15,000,000, since this was appropriated money from the State of Wyoming Legislature. The $15,000,000 cost included the pre-purchased equipment, the construction of the plant and the utilities necessary to tie into the existing steam mains and chilled water mains.

This estimate of projected comparative energy cost proved to be conservative. The ratio of gas cost to coal cost ($5.50 per million Btus for gas and $1.99 per million Btus for coal) was 2.76 for the assumed first year of operation. In 1983, the coal cost that has been contracted for by the University of Wyoming was $44.00 per ton, based on 12,500 Btu per pound coal which computes to be a cost of $2.35 per million Btu. In June, 1983, the natural gas cost was $4.85 per MCF, which computes to be $8.08 per million Btu. In 1983 the ratio of gas costs to coal costs on a million Btu basis was 3.44, as compared to 2.76 used in the economic analysis. The 1982 fuel costs would calculate to be a payback period of approximately 4.7 years in lieu of 6.9 years.

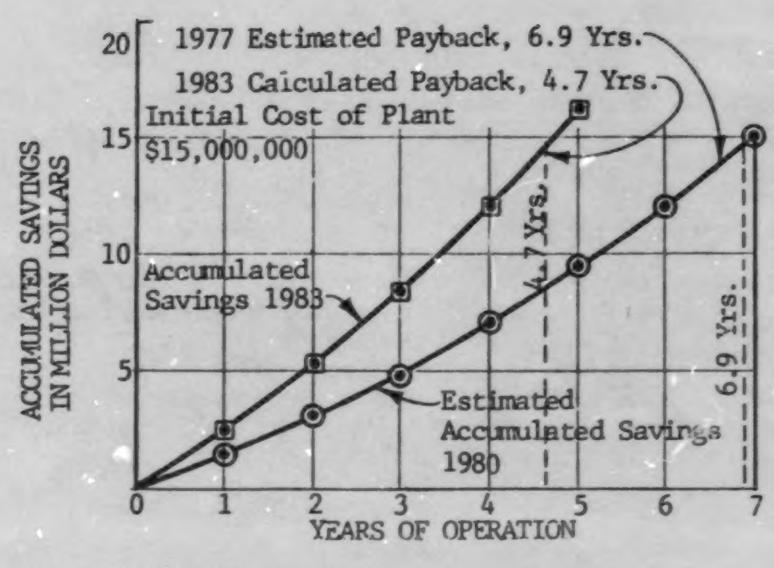
See the next page for graphical representation of the comparative coal and gas cost and the payback period based on net savings of using coal in lieu of natural gas.

Design Considerations

It was felt that the architectural design of the facility was extremely important because of the close proximity of the plant to the main campus. Therefore, a premium price was paid for an almost 100 percent glass building and the enclosing of the coal storage silos. It is felt that perhaps a quarter million dollar premium was paid for the all-glass enclosure. Both the daytime and nighttime appearance of the facility is exceptional. The Consulting Architect, W. C. Muchow and Partners of Denver, Colorado, did an outstanding job.



COMPARATIVE COST: NATURAL GAS VS. COAL



A walk-through tunnel was provided for the steam, condensate return and chilled water mains from the plant to the existing utility system.

Construction Problems

The fact that there were two prime contractors operating in parallel caused some problems in coordination, as could be expected. The boiler contractor was responsible for the installation of the field erected boilers, stokers, induced draft and forced draft fans, the breeching, the baghouse for pollution control, and the 100 foot stacks as required by the Department of Environmental Quality. The general contractor was responsible for the remainder of the facility. Very close coordination was required, particularly in the steel erection. The boilers were field fabricated; however, the convection sections were partially pre-assembled requiring that the boiler frame and convection section be erected simultaneously with the steel building frame. Pre-purchasing the boiler allowed time for the boiler components to be on site in time to match the building erection schedule. Additional coordination by the Engineer was required for the support of the breeching, induced draft fans, catwalk access to the various levels and control components on the boiler. As of June, 1983 after the completion of all pollution testing by the Department of Environmental Quality, the change orders amounted to less than one percent of the initial contract bid cost. There could be a small percentage of additional change orders in the final settlement, but the net cost will probably be not more than one percent of the initial bid cost.

Start-Up and Initial Operation

None of the operating crew for the University of Wyoming had had any experience in operating coal fired boiler plants, and of course there is considerable difference in the operation of a coal fired plant and a gas fired plant. There is a definite learning curve and training period. Maintaining an even bed of coals on the grate requires a number of adjustments for the spreader type stokers. There is no such thing as a completely automatic ash removal system. The ash removal from the main stoker hopper has to be manually initiated by the operators. Clinkers must be manually removed and adjustments must be made in the over-fire re-injection system, or else a considerable amount of unburned carbon will remain in the ash. Any conscientious boiler operator can learn these techniques over a period of time and this was certainly true of the University of Wyoming operators. The operation of the baghouse for emission controls is not as easy as one might assume. Care must be taken that too much unburned carbon is not carried over into the baghouse. There is always danger of ash carbon re-ignition in baghouse hoppers causing a burn-out of the bags. The automatic changeover for reverse air flow to clean the bags is an important factor and adjustments of controls are necessary for the successful operation of this type of pollution control system.

Although all of the controllers are microprocessors, the actuators are pneumatically operated with positive positioning relays. One of the primary start-up problems was allowing oil from the air compressors to get into the pneumatic lines which fouled the positive positioning relays, and air cylinders. After considerable effort to clean all of the pneumatic lines, the actuators and relays, the control system settled down and was able to provide complete the automatic operation during the tests by the Department of Environmental Quality. The microprocessing based control system is highly flexible and provides an extremely precise control system.

Conclusions

The University of Wyoming has constructed an efficient coal fired plant that will provide a low cost dependable source of energy for a long period of time.

COOLING SYSTEMS ENERGY SAVINGS - BACK TO BASICS

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The cost of providing both comfort and process cooling is increasing at an alarming rate. Much of the emphasis in energy conservation for chiller systems has been directed at demand and load control, especially since the development of microprocessors in energy management systems. With this increased use of on-line computer control systems, there has been a tendency to overlook the basic energy conservation principles of chilled water systems.

A thorough understanding of the operating principles of the chiller system will allow plant operators to improve and maintain the highest possible chiller system efficiency by applying proper operation and maintenance procedures.

A fundamental knowledge of operating theory and procedures for evaluating the chiller system can result in significant savings in energy costs. The use of off-line computer programs can simplify the calculation procedures and document the energy savings.

Fundamentals of Chiller Operation

The purpose of a chiller system is to remove the heating load from the room or unit to the atmosphere. In the drawing shown in Figure 1 a chilled water loop is used to transfer the heat load from a computer room to the chiller. The load is then transferred from the chiller to the atmosphere by the cooling water loop and the cooling tower.

The chiller uses the properties of its refrigerant to transfer heat at low temperatures from the chilled water loop and then give up heat to the cooling water at much higher temperatures. The most common refrigerants are ammonia and the freon refrigerants such as R-11, R-12, or R-22. The most important properties of a refrigerant is its ability to change phases at useful temperatures and pressures.

Refrigerants can be used to provide useful cooling because the properties of the refrigerant can be manipulated. When liquid refrigerant is at low pressures, the refrigerant can cool the chilled water by boiling in the evaporator. The energy removed in the evaporator for a given mass of refrigerant is called the refrigeration effect.

When the refrigerant vapor is at high pressures, the refrigerant vapor can be condensed by cooling tower water. The chiller's compressor increases the refrigerant's pressure from the evaporator pressure to the condenser pressure. This provides the change in refrigerant properties that will allow it to be condensed at the available cooling tower water temperature.

The final component in the chiller is the expansion valve. The expansion valve separates the high pressure condenser from the low pressure evaporator. As the refrigerant's pressure is reduced, some of the refrigerant flashes, lowering the temperature of the refrigerant. The energy content of the refrigerant, however, does not change. Reviewing the refrigerant cycle, the refrigerant picks up heat by boiling in the evaporator. The refrigerant vapor is compressed. The energy added to the refrigerant in the compressor is the heat of compression. The energy added by the compressor and the cooling load is removed from the refrigerant by the cooling water in the condenser. The refrigerant cools until it is liquified. The pressure of the refrigerant is then reduced by the expansion valve before returning to the evaporator.

The efficiency of a chiller is measured by the coefficient of performance (COP). The coefficient of performance is a dimensionless number defined as:

$$\text{Coefficient of Performance} = \frac{\text{Refrigeration Effect}}{\text{Heat of Compression}} \qquad \text{Equ. 1}$$

The condenser pressure sets the compressor discharge or head pressure. The higher the head pressure the more work that is required from the compressor to compress the refrigerant from the suction pressure to the discharge pressure.

Higher than normal head pressures are one of the most common causes of energy waste in chiller systems. The typical causes of high compressor head pressures are air in the refrigerant, high cooling water temperatures and condenser fouling. The prevention, detection and control of these problems can significantly decrease the cost of operating a chiller system.

Air in the Refrigerant

Air in the refrigerant is frequently a problem in chiller systems that operate with suction pressures below atmospheric pressure such as R-11. This problem can be identified when the actual liquid refrigerant temperature leaving the condenser is less than the saturated liquid refrigerant temperature based on the condenser pressure. The saturated liquid refrigerant temperature can be found in tables or graphs of the refrigerant's properties. The cost of air in the refrigerant for R-11 is about 2% for each degree difference between the actual liquid refrigerant temperature and the saturated liquid refrigerant temperature based on the condenser pressure.

Air in the refrigerant can be prevented by stopping leaks in the refrigerant piping. Purging the system will remove air that is already in the refrigerant.

High Cooling Water Temperatures

Another cause of high compressor head pressures is high cooling water supply temperatures. The cooling water supply temperature sets the condenser pressure by limiting the liquid refrigerant temperature. Higher cooling water supply temperatures therefore result in higher condenser pressures and increased compressor energy usage.

Several common causes of high cooling water supply temperatures are undersized cooling towers, improperly set fan shutoffs and uneven water distribution. All of these problems can increase the chiller operating costs by approximately 1.5% for each degree increase in the cooling water supply temperature.

Many cooling towers can never meet their design performance. The actual performance of a cooling tower compared to its design performance can be measured using the Cooling Tower Institute's Performance Test. A requirement that a new cooling tower should pass the Cooling Tower Institute's Performance Test should be a part of the bid package for any custom-designed cooling tower.

Some cooling towers have thermostats that control one or more of the cooling towers fans as the cooling water supply temperature is lowered. If this thermostat is improperly set, the fan motor is shut off prematurely, saving energy in the low horsepower cooling tower fan while wasting energy in the high horsepower compressor of the chiller.

One of the most common problems with cooling towers is uneven water distribution. Uneven water distribution can result from plugged spray nozzles, spray nozzles with poor spray patterns or from collapsed tower fill. Flow distribution problems can usually be detected by observing uneven splash patterns for the water in the cooling tower basin.

Condenser Fouling

Fouling on the condenser tube walls probably wastes more energy than any other problem with chilled water systems. The fouling film interferes with the heat transfer in the condenser by insulating the tube wall. This has the same effect as having a clean condenser tube wall and a higher cooling water supply temperature. The most common types of fouling are scale, biological fouling and deposits.

Scale can consist of inorganic precipitants such as calcium carbonate or calcium phosphate or could be the result of corrosion of the cooling system. Scale formation can be avoided by preventing saturated concentrations of inorganic compounds and through proper water treatment.

Biological fouling is the attachment of microorganisms from the bulk cooling water to a heat transfer surface. These bacteria can generate slime which will cause additional insulating effects.

The temperature in cooling water towers along with organics scrubbed from the air can create ideal conditions for bacterial growth. The growth of bacteria can be controlled with the use of biocides and by minimizing the dissolved organics in the cooling water by stopping leaks and in some cases filtration of suspended organic solids.

Deposits result from solid particles settling in the condenser tubes. Fouling increases as the deposit layer grows. The increased fouling increases the compressor horsepower requirements.

Deposits can be controlled by filtration, chemical dispersants and by maintaining condenser tube velocities of greater than 3 to 4 ft/sec. Tube velocities are generally between 6 to 9 ft/sec in condenser tubes.

Fouling of condenser surfaces is usually detected by high compressor head pressures or during maintenance shutdowns. The compressor head pressure can be increased by other factors besides fouling such as high cooling water supply temperatures and air in the refrigerant. Opening of the condenser for inspection is costly and can also present problems since many units cannot be shut down during the cooling season and fouling can present an economic problem long before it becomes visible, particularly in the case of biological fouling. Therefore, neither head pressure nor inspections should be the sole basis for determining the cleanliness of a condenser.

These problems can be avoided by measuring the performance of the condenser. Fouling films are too thin to be used to directly measure their resistance to heat transfer. This problem can be overcome by measuring the resistance to heat transfer of the entire tube wall, including any fouling films.

The measure of the condenser's performance is called the heat transfer coefficient. The heat transfer coefficient, U, has units of BTU/(hr(sq ft)°F). The higher the heat transfer coefficient the better the heat transfer rate through the tube walls and the lower the head pressure. As fouling increases the heat transfer coefficient is lowered and the head pressure increases.

For a clean condenser using a freon gas as a refrigerant and cooling water, the heat transfer coefficient is usually about 500 BTU/(hr(sq ft)°F). The clean heat transfer coefficient can be calculated from operating data on the new condenser or from data immediately after the condenser has been cleaned and inspected.

The heat transfer coefficient can be calculated from

$$U = Q/(A \times F \times LMTD) \qquad \text{Equ. 2}$$

where

U = Heat transfer coefficient, BTU/(Hr(Sq. Ft.)°F)

Q = Condenser load, BTU/Hr

A = Condenser Area, Sq. Ft.

F = Temperature correction factor for the heat exchanger configuration

$LMTD$ = Log mean temperature difference

$$= (DT2 - DT1)/\ln(DT2/DT1) \qquad \text{Equ. 3}$$

$DT1$ = Temperature difference between hot fluid out and cold fluid in

$DT2$ = Temperature difference between hot fluid in and cold fluid out

If the clean and actual heat transfer coefficients are known, the fouling factor can be calculated by Equation 4.

$$ff = \frac{1}{U} - \frac{1}{U_c} \qquad \text{Equ. 4}$$

where

ff = Fouling factor (Hr(Sq.Ft.)°F)/BTU

U = Actual heat transfer coefficient

U_c = Clean heat transfer coefficient

The fouling factor is a design term that is used to calculate how much additional surface area must be added to a heat exchanger to allow for unavoidable fouling.

The actual fouling factor cannot be calculated if both the clean and actual heat transfer coefficients are not known. Changes in the heat transfer coefficient can always be monitored to determine if a heat exchanger is becoming fouled.

Figures 2 and 3 show an analysis of a chiller at a hospital in the Southeastern United States using the COOLING C.A.R.E.™ computer program. In the baseline case, the heat transfer coefficient was found to be 285.9 BTU/(hr(sq ft)°F). The low heat transfer coefficient showed that the condenser was fouled.

Since the cooling tower had accidentally been contaminated with oil, the fouling was assumed to be organic in nature.

After changes in the water treatment program to compensate for this type of fouling a second set of data was taken as shown in the current case. In the current case the heat transfer coefficient was calculated to be 516.6 indicating a clean condenser.

The performance of the chiller in the baseline and current cases could not be compared directly because of the change in load from the baseline to the current case. So that the savings provided by the clean condenser could be documented the computer calculated what the operating conditions for the current case would be if the heat transfer coefficient had remained at 285.9.

This data is shown in the Impact versus Baseline U column. These calculations show that cleaning the condenser saved $67.5 per day or about 18 percent of the compressor operating cost when comparing the clean current case to the fouled Impact versus Baseline U case.

Summary

In order to achieve the best performance from a chiller system a basic maintenance program must be instituted that will ensure that common problems in chiller systems are not overlooked. This maintenance program should stress checking for air in the refrigerant, problems with the cooling water tower and for fouling of the condenser. Condenser fouling is best determined through regular calculation of heat transfer coefficient, either manually, or through computer programs such as COOLING C.A.R.E.™ This maintenance program must be maintained for chiller systems even when energy management systems are used to minimize the load on the chiller.

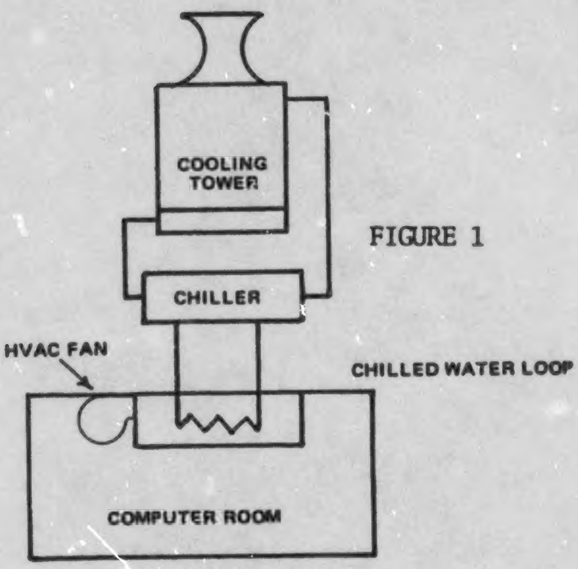
COOLING TOWER
CHILLER
HVAC FAN
CHILLED WATER LOOP
COMPUTER ROOM

FIGURE 1

FIGURE 2

CASE STUDY

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                                                DATE: JUNE 2, 1983
                                                UNIT: NO. 3

                     ***********************************
                     *          COOLING UNIT           *
                     *ENERGY MANAGEMENT STATUS REPORT*
                     ***********************************

                                   BASELINE         CURRENT        IMPACT VS.
PERIOD                             9/13/82          9/16/82        BASELINE U

LOAD
     TONS                            145.7            297.7            297.7
     1000 BTU/HR                    1748.7           3572.4           3572.4
     LOAD FACTOR                     100.0            204.3            204.3

COMPRESSOR EFFICIENCY %               25.9             52.1             52.1

COEFFICIENT OF PERFORMANCE             6.3              5.9              4.8

REFRIGERATION EFFECT
    BTU/LB                            51.9             51.2             48.7

REFRIGERANT CYCLE
     THEORETICAL HP/TON                .75              .80              .98

COMPRESSOR OPERATING COST
     $/MILLION BTU                     6.7              3.5              4.3
     %                               100.0             52.8             64.6

     $/DAY                           280.6            302.7            370.2
NET SAVINGS, $/DAY                                            67.5


                          COOLING UNIT CONDENSER


HEAT TRANSFER COEFFICIENT, U
  BTU/(HR (SQ FT) F)

     ACTUAL                          285.9            516.6            285.9
     CLEAN                           500.0            500.0            500.0

ACTUAL HEAT TRANSFER                  1.00             1.81             1.00
  COEFFICIENT RATIO

HEAT TRANSFER RATE                  2028.1           4178.3           4313.5
     1000 BTU/HR

CONDENSER INSIDE SURFACE AREA        550.0            550.0            550.0
     SQ FEET

COOLING WATER VELOCITY FT/S            8.9              9.2              9.2


LOG MEAN TEMP. DIFF. F                13.7             16.2             28.4

DEGREES OF SUBCOOLING F                0.0              0.0              0.0
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FIGURE 3

CASE STUDY

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                                           DATE: JUNE 2, 1983
                                           UNIT: NO. 3

                          COOLING UNIT INPUT DATA

COMPRESSOR
     SUCTION PRESS (PSIG)              36.0           36.0           36.0
     SUCTION TEMP. (F)                 39.2           39.2           39.2

     HEAD PRESS. (PSIG)               105.0          110.0          129.7
     DISCHARGE TEMP. (F)              112.8          116.7          130.7
     BRAKE HORSEPOWER                 423.7          457.1          559.0

CONDENSER
     INLET VAPOR TEMP. (F)            112.8          116.7          130.7
     PRESS. (PSIG)                    105.0          110.0          129.7
     OUTLET TEMP. (F)                  93.0           95.9          106.2

EVAPORATOR
     PRESS. (PSIG)                     36.0           36.0           36.0
     OUTLET TEMP. (F)                  39.2           39.2           39.2

MISCELLANEOUS
     REFRIGERANT TYPE                  12.            12.            12.
     POWER FACTOR                      1.00           1.00           1.00
     ELECTRICAL COST ($/KWH)           .037           .037           .037
       (BASED ON CURRENT COSTS)
     REFRIGERANT FLOW RATE           33695.         69761.         73354.
       LB/HR
     RUN TIME (HR/DAY)                 24.0           24.0           24.0


                         CONDENSER INPUT DATA


NUMBER OF TUBES                       294.0          294.0          294.0

TUBE ID INCHES                         .650           .650           .650

TUBE LENGTH FT                         11.0           11.0           11.0

NUMBER OF TUBE PASSES                   2.0            2.0            2.0

NUMBER OF SHELL PASSES                  1.0            1.0            1.0

COOLING WATER SUPPLY TEMP F            86.0           86.0           86.0

COOLING WATER RETURN TEMP F            89.0           92.0           92.2

COOLING WATER FLOW RATE GPM          1352.1         1392.8         1392.8

TEMP CORRECTION FACTOR                  .94            .91            .97


     (PRESSURE IN PSIG. NEGATIVE PRESSURES ARE IN INCHES OF VAC HG)
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Casedy

Wetegrove

HIDDEN ENERGY COSTS WHICH AFFECT YOUR AIR-CONDITIONING BUDGET

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Hidden Energy Costs Which Affect Your Air-Conditioning Budget
Cooling System Operation

The impact of rising energy (electricity, oil and gas) and water costs on energy budgets during the last decade has been dramatic. Those managers responsible for the heating and cooling costs in their facilities have had to undergo a fundamental change in the way they look at energy costs. Up until a few years ago, when energy was not a major budget concern, heating and cooling budgets were generally assigned to a lower operating level.

In some facilities the heating and air-conditioning budget can constitute 50 percent or more of the total operating budget. In a typical university the utility budget is usually 15-20 percent of the total operating budget. Available data indicate annual costs are in the range of $1-2 per gross square foot. Regardless of whether the facility is a commercial building, university or hospital, heating and cooling costs usually make up 50 percent or more of the utility budget.

Managers today are being forced to become more involved in the operation of their heating and cooling systems than ever before. Unless they have an engineering background, most managers are not familiar with the operation of boilers and chillers. Therefore, in order to maintain control over costs, they are learning much more about this equipment than was required ten years ago.

What they are discovering is that operating costs continue to rise, even with equipment efficiency maintained. The best that can be hoped for is to minimize the effect of increasing energy costs by operating all equipment at design efficiency. We will confine this discussion to water cooled electrically driven centrifugal chillers, since they are most commonly found in commercial and institutional buildings.

Most electric utilities across the country are predicting rate increases of 5 - 20 percent per year for the next several years. This means that the cost of operating a chiller will increase each year. The energy manager's goal is to counteract this effect by operating his chillers at their peak efficiency.

In order to accomplish this goal, you, as an energy manager, must ask yourself these four basic energy questions:

1. Where are you now? What is the current energy efficiency of your cooling equipment?

2. Where do you want to be? What is the design efficiency of your cooling equipment?

3. How are you going to get there? You must know the reasons why equipment is operating inefficiently, and then develop an action plan to correct the problems.

4. How do you monitor your progress? Once you have achieved your goals of efficient equipment operation and energy management, you should monitor actual efficiency versus design efficiency on a periodic basis.

The efficiency of an electrically driven chiller is usually determined by measuring KW/ton, i.e., the amount of electricity required by the compressor motor to produce one ton of refrigeration. However, this figure will vary with changes in condenser (cooling tower) water temperature, chilled water temperature and percent load on the machine. Most air conditioner manufacturers supply a table for each particular model listing the kilowatt consumption and tons produced at given condenser water and chilled water temperatures at 100 percent load conditions. If this information is not available, you can determine base-line data for your chiller(s) by first making sure your condenser and chiller tubes, and fan/coil units are clean, and then running the unit(s) at full load for at least 30 minutes. Record all of the necessary data which include chilled water gpm, chilled water in and out temperature difference, condenser water in and out temperatures, and refrigerant suction and head pressures and temperatures. Also be sure that the refrigerant side of the unit is properly charged with refrigerant and is free of air and water. The results obtained in this manner establish your efficiency goal.

There are several factors which will affect the efficiency of a chiller, some of which you have control over, and some independent of your control. These are:

1. Condenser water temperature as it leaves the cooling tower. If temperature is elevated because of high ambient wet bulb temperature, it is beyond your control. If caused by a fouled or inefficiently operated cooling tower, it can be corrected. In either case, each degree increase in tower water temperature results in a 1 - 2 percent increase in electrical power use. Your goal is to operate the tower so as to produce the lowest temperature water possible, depending on the design of your chiller. Consult with the manufacturer or your equipment service company to determine minimum condenser water inlet temperatures for various load conditions. Some operators run higher cooling tower water temperatures than necessary in the mistaken impression that they are saving energy by cycling the cooling tower fans on and off. The resulting high refrigerant head pressure puts an added burden on the compressor motor which consumes far more energy than is saved by cycling the much smaller fan motors. Consult your cooling tower service company to determine if the tower is cooling water sufficiently with respect to the outside wet bulb temperature.

2. Fouled condenser tubes. The condenser's function is to transfer heat from the compressed, hot, refrigerant gas to the condenser cooling water (tower water). The resulting temperature of the condensed refrigerant determines the head pressure on the compressor. Any increase in the head pressure causes an increased electrical demand on the motor, hence increased operating costs. Deposits of any kind on the waterside tube surfaces prevent efficient transfer of heat from the refrigerant to the cooling water. This fouling is usually caused by mineral scale, microorganisms ("slime"), dirt and silt or a combination thereof. Experience has shown that fouled condensers are the primary cause of loss of efficiency in chillers, and further, that slime deposits caused by bacterial growth, are the most commonly occurring foulant. A more detailed look at microorganisms will be given later on in this discussion. Table 1 gives examples of the costs associated with fouling on condenser tubes.

3. Chilled water temperature. For each degree the chilled water temperature is raised, electrical consumption is reduced 1 - 2 percent. The chilled water temperature should be maintained as high as possible, depending on comfort conditions. It stands to reason that chilled water temperatures must be lower on hot, humid days, but they should be raised on days when the outside wet bulb temperatures are low. Some computer controlled systems monitor the outside wet bulb temperatures on a continuous basis and raise and lower chilled water temperatures accordingly.

4. Fouled evaporator tubes. This problem occurs much less frequently on evaporator tubes than on condenser tubes. Even so, the effect on energy consumption is just as severe. When evaporator tubes are fouled with deposits, usually iron oxide or microorganisms, the chilled water does not give up its heat to the liquid refrigerant efficiently. The net result is that the chilled water is not cooled sufficiently, and the chiller has to work harder to achieve the desired chilled water temperature. This results in higher operating costs.

   The primary problem on the waterside of chilled water systems is corrosion, but growth of microorganisms can also be troublesome. Proper chemical treatment for prevention of corrosion and scale, and routine checks for bacterial activity will keep chilled water systems in good operating condition. The use of corrosion coupons is strongly recommended for monitoring corrosion in chilled water loops. When a biocide is required, factors to consider are compatibility with the chemical program being used and the pH of the system water.

5. Dirty or fouled fan/coil units. Fan/coil units that are dirty on the airside or fouled on the waterside prevent efficient transfer of room heat to the chilled water. In order to achieve the desired living space temperatures, the operator will lower the chilled water temperature, increasing energy consumption. The airside of air handling equipment, fan/coil units and filters should be inspected frequently, and cleaned when necessary. When it is suspected that a fan/coil unit is fouled on the waterside, it should be removed for cleaning. In systems that have not been chemically treated, or have not received the proper chemical treatment, it is not uncommon to see fan/coil units completely plugged with iron oxide deposits. The use of sidestream filters on chilled water systems is strongly recommended as the best means of removing any type of suspended matter. This is true even for systems that are receiving proper chemical treatment.

   Monitoring the efficiency of a centrifugal chiller is time consuming but necessary, if control over operating costs is to be gained. One of the key areas to monitor is condenser efficiency. It is important to know if the refrigerant is being cooled by the condenser water to design specifications, and if not, how much energy is being wasted. In order to help customers do this easily, Nalco's Watergy Group has equipped each of its sales representatives with a Hewlett Packard HP-41 hand-held computer. Once all of the data has been gathered, the condenser efficiency and the overall KW/ton efficiency can be obtained in a few minutes using the Watergy Chiller Efficiency Program. In this manner, potential problems are caught early and corrective action can be taken.

Biological Fouling - A Major Problem

Biological fouling in cooling systems results from the growth of algae, fungi, and bacteria. These microbes enter in small numbers with the makeup water and are scrubbed from the air by cooling towers. The organisms find the cooling system a very hospitable environment.

Algae, which are microscopic plants needing only water and sunlight, grow on tower decks and slats. They form dense mats that cause plugging of distribution holes and filter screens. More importantly algal waste products and dead cells become food for bacteria.

Biocides commonly used for control of algae are chlorine and tributyltin oxide (TBTO). Chlorine will kill algae on contact, but often will not penetrate to the source of algae growth. Biocides containing TBTO are more effective than chlorine because the TBTO penetrates the algal mat and kills the algae at its source. TBTO, a non-oxidizing biocide, kills algae in much the same manner as a herbicide kills weeds. TBTO is beneficial to wood cooling towers because it is absorbed into the wood. This makes it more difficult for algae to grow.

Many types of troublesome bacteria can be found in cooling systems. The bacteria establish themselves on surfaces where they stick in their own slime layer and extract nutrients from the water flowing past. In addition, this sticky, glue-like layer holds on to any suspended matter which it contacts.

The effects of this bacterial slime layer include plugged small recirculation lines and condenser tubes, reduced water flow in large diameter tubes, reduced heat transfer efficiency, formation of hot spots, increased scale formation, and microbiologically induced corrosion. Slime deposits less than 1/100 inch thick on a condenser tube will cause a centrifugal chiller unit to consume up to 10 percent more energy than when the tubes are clean. Anaerobic zones under this thin layer will result in pitting-type corrosion, which can eat through tubes and pipes in a few weeks.

Fungi growing on wood sections of cooling systems destroy lignin and cellulose weakening the wood to the point where it must be replaced. Once fungal attack begins, it is nearly impossible to stop because the fungi penetrate into the wood.

Control of microorganisms in cooling systems requires regular use of the right chemical in the right way at the right time. Oxidizing biocides, bio-dispersants, and non-oxidizing biocides all have uses. Because of the importance of good microbiological control, Nalco Watergy has equipped its technical sales representatives with, and made available to customers, a Microbio Quick Test Kit. This new, state-of-the art test kit allows determination of total aerobic organism count in just 30 minutes. Running the test once or twice a week allows the user to keep microorganisms under control, and, at the same time, maintain better control over the amount of biocide being fed.

Chlorine and bromine are the two most commonly used oxidizing biocides. They act by chemically burning nitrogen and carbon in the microbes and their slime. Oxidizing biocides are 2 - 20 times as effective for preventing and removing slime deposits when bio-dispersents are used.

Bio-dispersants act to strip off dead layers of microbes and expose more of the slime to the chlorine, bromine, or non-oxidizing biocide. A considerable amount of research on biofouling is being conducted by Nalco's Microbiology Laboratory. One of the more interesting discoveries is that while all biodispersants are surfactants, by no means are all surfactants good biodispersants. And within the class of compounds classified as biodispersants, some show remarkably better performance in penetrating slime masses than others.

Non-oxidizing biocides are organic chemicals that act as metabolic poisons to algae, bacteria, and fungi. Non-oxidizing biocides, such as isothiazolin, are useful in severely fouled systems and in cases where a heavy level of organic contamination makes chlorine or bromine use impractical.

More energy loss in cooling systems occurs as a result of poor control of microorganisms than for any other single reason. The proper biocontrol chemical must be added to the cooling water at the recommended dosages and times without fail. Many years of water treatment experience have shown that those who maintain good control of microorganisms have the fewest problems operating their equipment at design efficiency. Table 2 lists the problems microorganisms can cause in cooling systems.

TABLE 1

EXCESS COSTS DUE TO CONDENSER FOULING

A/C Tonnage	.001 Fouling Factor (1/84")	.002 Fouling Factor (1/42")	.003 Fouling Factor (1/32")
500	$ 3,400	$ 7,400	$ 10,400
1000	6,800	14,800	20,800
2500	17,000	37,000	52,000
5000	34,000	74,000	104,000

Conditions:

1. Unit operating at 100% load
2. Unit operating 8 hrs/day, 240 days/year
3. One ton of A/C consumes 0.7 KWH
4. Electricity costs 5.0¢/KWH

TABLE 2

COOLING SYSTEM PROBLEMS CAUSED BY MICROORGANISMS

	Microorganism		
Component	Algae	Bacteria	Fungi
Ton Stack	-	-	W
Plenum	-	-	W
Mist Eliminator	-	W	W
Distribution Trays	N, P	P, D	W, P
Partitions		-	W
Fill Lumber	N, P	W, D	W
Structural Members	N, P	-	W
Tower Basin	D	D	D
Pumps	P	-	P
Screens	P	P, F	P, F
Piping	P	P, F, D, C	P, F
Heat Exchangers	P	P, F, H, C, D	P, F, H
Process Equipment	P	P, F, H, C	P, F
Sumps	D	D, C	D

W = Wood decay
H = Heat transfer resistance
D = Deposits of sludge or scale
C = Corrosion

F = Flow resistance
N = Nutrient supply
P = Plugging

How Our Energy Management System Has Changed the Way We Run Our Physical Plant

By Paul F. Barrett
Massachusetts Institute of Technology

Introduction

In my talk today, I will describe how the use of our energy management systems has changed the way we operate our physical plant. But first I would like to give you some idea of the type of place MIT is and how we operated before the advent of our facilities control system (FCS). We have about 110 buildings containing almost 9,000,000 square feet of floor area on a campus of 130 acres. It is a research-based institution with 9,000 students divided almost equally between undergraduate and graduate students. We have a year round university community of about 15,000 people. Our energy bill last year was $12,500,000.

Like many schools, MIT experienced explosive growth in the sixties and early seventies. When I arrived as a new construction administrator in 1962, we had a gross floor area of about 3,750,000 square feet. By the time I transferred from our engineering and construction group to an operations position in 1976, we had more than doubled that area. This rapid growth produced many operating problems, particularly in the heating, ventilating and air conditioning area.

Background

Traditionally, the plant had depended upon mechanics assigned to specific buildings as operators. Their success was measured in inverse ratio to the number of complaints received from the faculty and researchers resident in the building. As the number of buildings grew so did the number of operators, going from about 20 in 1960 to over 60 by 1974. The situation was fairly chaotic in the mid-sixties when, in two years, we completed 9 buildings, including 500,000 square feet of laboratory facilities.

At the management level, information received on the condition of mechanical facilities and operational problems was unreliable and sketchy, reflecting the hands-on tinkering style of coping with the problem of the moment. In addition, managers had offices on the second floor of our building while foremen and hourly employees worked out of the first floor. This led to an "upstairs/downstairs" relationship between the two groups. The first-line supervisors tended to be selected because they excelled in quick-fix repairs, and their managers were generally engineers with problem-solving skills but neither the time nor feedback system for instituting effective management procedures.

It was against this background that the energy crisis of the early seventies burst upon us, necessitating control setbacks which were almost impossible to achieve on a consistent basis with our wide diversity of HVAC systems. After the usual variety of relatively effective quick-fix energy conservation measures, we initiated a series of discussions and feasibility analyses on energy monitoring and control systems in 1974 and 1975. An accurate and complete inventory and condition evaluation of our several hundred HVAC systems followed. The results, while discouraging, were a strong stimulus to press ahead with the new system.

A performance specification was drawn up for a direct digital control energy monitoring and control system for 34 of our most energy-intensive buildings. In January 1976, a contract was awarded for the system which would control 4,000,000 square feet, of which about 1,000,000 were residential and the remainder laboratories, classrooms and offices. Although representing about half the total plant area at that time, these buildings used more than three quarters of all the campus energy. Bill Dickson, then Plant Director, selected the most knowledgeable HVAC supervisor and teamed him up with the plant business manager, with the directive to get a new system on line as soon as possible. He realized that the task would never get done if he assigned it to a joint engineering/operations committee.

It was about this time that I moved from the new construction group to supervision of day-to-day plant operations. It was fortunate that I brought with me a thorough knowledge of all the new generation of buildings and a minimum of ingrained operational biases. As the FCS became a reality, we operating people went through many of the conflicts familiar to those of you that have installed these systems -- distrust, frustration, anger and impatience that things would never stabilize.

During late 1976 and early 1977, we experienced a series of computer crashes as we went through the startup and shakedown process of bringing buildings on line. The standard response of mechanics when something did not work was to blame the computer. Our former HVAC supervisor, turned computer-control specialist, had a lot of missionary work to do.

Over a period of six to nine months, we systematically eliminated computer software anomalies, relocated sensors and began to develop the credibility of the system. Fortunately, the senior administration and our faculty were both understanding and sympathetic with our problems. By mid-1977, we had learned to live with FCS and began to capitalize on some of the management opportunities offered by the new system.

Location of FCS

At first, we didn't fully recognize the far-reaching management implications of the location decision for the FCS monitors. Because we had space available, we initially put them in a building adjacent to our central heating plant. When the question arose of who would do the monitoring around the clock, it seemed logical to consider training the heating plant watch engineers for this work. They were already maintaining a 24-hour rotating schedule. As we started to put this into effect, we immediately received a grievance from the plant engineers (all of our Physical Plant hourly employees belong to an AF of L building service employees local). They felt very uncomfortable getting involved with events outside the boundaries of the plant and wanted no part of the computer. With the grievance in hand, we began to rethink our initial decision in relation to management control of a very critical operational tool. As a result, we pulled back and after a more thorough review, assigned the work to a clerical team supervised by a former mechanical services foreman.

The FCS monitor and report printers were moved eventually to what had become the plant operational center in the midst of our mechanical shops. Tom Vacha, our Superintendent of Building Operations, described this center in his Oklahoma City meeting paper Establishment of an Integrated Physical Plant Control Center. The location of the center greatly improved inter-unit cooperation by making the equipment and its operators familiar elements in the daily routine of building operations. Mechanics and supervisors in the course of regular activities involving shutdowns, emergencies, work orders, etc., came into the center and could see and begin to understand how the FCS operated. We also took this opportunity to break with the "upstairs/downstairs" tradition and move managers downstairs where the action was.

Organizational Structure

In the sixties, the mechanical operations group was divided into three parallel units, headed by assistant foremen, each responsible for an area of the campus and reporting to a foreman who in turn reported to the superintendent of mechanical services. (FIGURE 1). As I pointed out earlier, these groups tended to be emergency response oriented. Individual building efficiency of operation varied widely depending upon the skill or lack thereof of the assigned mechanic. Building design deficiencies were difficult to isolate and correct because of the lack of valid performance data. Over a third of our personnel resources were devoted to the watch activities of watch mechanics touring the buildings around the clock to assure (hopefully?) that equipment was still operating and no disaster had occurred. The general reputation and morale of the group was low. Somehow, we never seemed to catch up with the avalanche of new buildings.

As the building construction program began to taper off in the early seventies, the energy crisis arrived with its extensive effects on operations. Budget pressures on managers increased and efforts to improve operating efficiency became paramount. We began the difficult task of trying to restructure and streamline plant operations. The introduction of our new FCS in 1976 was the catalyst which made radical change possible.

Because we were receiving excellent operating data from FCS, we realized we no longer required the less-skilled watch mechanics whose primary function was monitoring. In addition, we could almost instantaneously determine whether a mechanic had made a successful repair to a system or was having trouble getting things back on line. This pointed up our need for mechanics better trained to respond to operating problems and make necessary on-the-spot adjustments and repairs.

In cooperation with the union we reclassified all mechanics into one category and instituted a training program for all personnel. We greatly increased our communications capability -- more than doubling our portable two-way radios and tripling the number of voice pages. Quick and easy communication among supervisors, CRT operator/dispatchers and mechanics became a way of life. At the same time, we started an evening shift, primarily to perform preventive maintenance and repairs as well as providing the necessary operating coverage. A night shift with similar duties followed shortly. We found that both our morning start-up problems and daytime repair shutdowns greatly diminished. In the process we were able to begin to reduce staffing, by attrition, since we no longer had to maintain the extensive rotating watch shifts around the clock.

With FCS came better control stability due to the increased reliability of the electronic systems. This permitted us to focus manpower on specific aspects of improving operating efficiency, such as preventive maintenance and water treatment. Over several years a new mechanical/electrical organization evolved. (FIGURE 2). As you can see, the separated vertical shape of the sixties' organization chart changed to a horizontal array with responsibility dispersed to a group of autonomous managers supported by training and preventive maintenance supervisors. Total number of personnel was reduced by 10 percent during a period in which operating square footage increased by 25 percent. Looked at another way, by using FCS with its less mechanically skilled operators and by increasing the supervisory/management staff, we were able to increase our field mechanics' productivity from about 100,000 square feet operated and maintained per mechanic, to 160,000.

Personnel & Training Considerations

As we began to experience the information feedback benefits of FCS, we had to rethink our personnel selection and training strategies. As I indicated earlier, we had, after much consideration, assigned CRT duties to clerical grade people, both men and women. With intensive hands-on training, an organized information file and a good supervisor, we found we could attain adequate response skills in three or four weeks.

With about 2500 incoming calls a month to the center, along with CRT & fire alarms, the ability to receive and process information in an accurate and efficient manner is paramount. During off-hours and periods of lower activity the console operators process work orders, update schedules and perform various clerical duties. Because the FCS is user-friendly and we always have mechanics on duty during off-hours, the console operators are able to respond to a wide spectrum of mechanical events and problems. In addition, we have mechanical supervisors assigned on a weekly schedule to carry a page as off-duty backup.

Continual training and retraining of mechanics has become a necessity. We accomplish this with a full-time training supervisor who is also responsible for keeping building maintenance procedures current. Our new managers and supervisors are selected for their management skills and potential in addition to basic technical ability. In some instances, fortunately very few, existing supervisors were not able to adapt to the changed ways of operating our facilities. They couldn't adjust to the need to freely share information laterally and delegate responsibility. In several cases, we had to hire key managers from the outside, something seldom done in prior years. Our plant operation normally drew all its first and second tier supervisors from long-term hourly personnel.

Operating Strategy

Building operating strategy has been assigned to our FCS group, and they are responsible for climatic response decisions in all buildings, whether FCS controlled or not. They have several weather monitoring stations on campus and keep current with forecast data. They orchestrate the seasonal turning on and off of our large steam mains and change overs from heating to cooling and the reverse. When building operating schedules need to be changed to respond to different research or academic needs they meet with administrators or faculty as necessary to develop new operating reference sheets (FIGURE 3).

We no longer have to depend upon Sam, the mechanic, in Building X to remember that the peculiarities of the building require the steam on when the temperature drops below 60°F. He usually either forgot or turned it on too soon. With FCS, we refine set points for a building over a period of time and gradually optimize the energy use/occupant tolerance ratio. Because of the reliability of the electronic system, we are able to consistently produce steady state conditions without the frustrating drift of earlier individual building control systems.

Economic Benefits

Tom Shepherd, Associate Director of Physical Plant at MIT, evaluated both the tangible and intangible dollar benefits of our FCS for a recent ASHRAE seminar paper. He reported cost avoidance levels for maintenance efficiency at half of the cost avoidance realized from energy conservation and optimization use of the FCS. With an estimated 1983 FCS energy cost avoidance of $2,400,000, this means another approximately $1,200,000 we do not have to spend. (FIGURE 4). It's a very significant element in satisfying a recent university-wide three year retrenchment edict directed at non-energy costs.

Second Generation FCS

In 1978 and 1979, we were planning several new buildings and had to face the problem of expanding our FCS which was designed to accept at least an additional 1,000 points. The original supplier of the system suggested we consider new technology utilizing distributed processing with local microprocessor unit controllers. After canvassing the market and considering the unsettling effects to our central system of a major addition of points, we decided to go the distributed processing route.

Although the original system had been installed keeping the existing building pneumatics as back-up, we have forgone these pneumatic controls entirely on the new buildings and use only unit controllers directly controlling motors, valves and dampers, etc. This decision stemmed from our experience on the first system which went through only very brief periods when both central computers were down simultaneously. (By 1982 we had accumulated less than two hours of joint central computer downtime over the first five years of full operation). We just could not justify the neglible advantage of maintaining a back-up system in the face of this reliability.

The new system with a single central monitoring computer now has 44 unit controllers in 16 buildings, with some operational for almost two years.(FIGURE 5). Here I should emphasize the importance of the central computer in our distributed system. While we could operate the new buildings independently with unit controllers and gain modest energy savings from today's more energy efficient HVAC systems, we need the central to achieve management savings. The central provides us with the feedback and control necessary to make our management system work. These buildings came into service with only a fraction of the control shakedown problems of the 34 building central system.

Now all we need to do is to convince our design engineers that it is no longer necessary to prove the overall cost benefits of our FCS before including it in each new building design. As our Building Operations Superintendent puts it very bluntly, "You don't raise questions about whether to put a roof on every new building, do you?"

Future Direction

We plan to continue a policy of installing unit controllers in existing facilities, based primarily on operational needs. An example is one of our newer laboratory animal facilities which is a high risk building for us because of the vulnerability of the valuable colonies of research animals. Over the years, we have been responsible for the unfortunate demise of our share of fruit flies, rats, mice etc., so this building received one of the first micros tied back to the central unit.

Last month we brought on line an FCS installation at a 3,000 ton satellite chilled water plant so that we can operate it remotely from our central utilities plant. Within the next five years we will begin to replace our 1970 vintage boiler controls in the central plant with microprocessors.

A future project is to rewrite our preventive maintenance program software and integrate it with FCS to reflect equipment runtime as well as malfunction or failure experience.

We know we have only just begun to tap the interactive potential of the system. A recent feature we programmed was a family of reminders tied to master temperature sensors around the Institute. For example, when the temperature drops below 32°F, a message on the CRT may tell the operator to have a mechanic check an area particularly vulnerable to freezing. In spite of our best maintenance efforts, we still have a number of chronic cold weather trouble locations.

Starting this month, we plan to assign one of our most knowledgeable energy conservation engineers to the operations center to see what further cost avoidance benefits we can accrue by fine tuning the operation of FCS. In spite of what I believe is a generally satisfactory level of performance, we still have people in our plant who think we can do better with closer and more skilled monitoring and manipulation of systems.

We have thought about extending the system to our more than 100 elevators to monitor conditions and provide better operating control. In this case, we're less confident of operational payback due to difference in tempo between institutional and commercial elevator use.

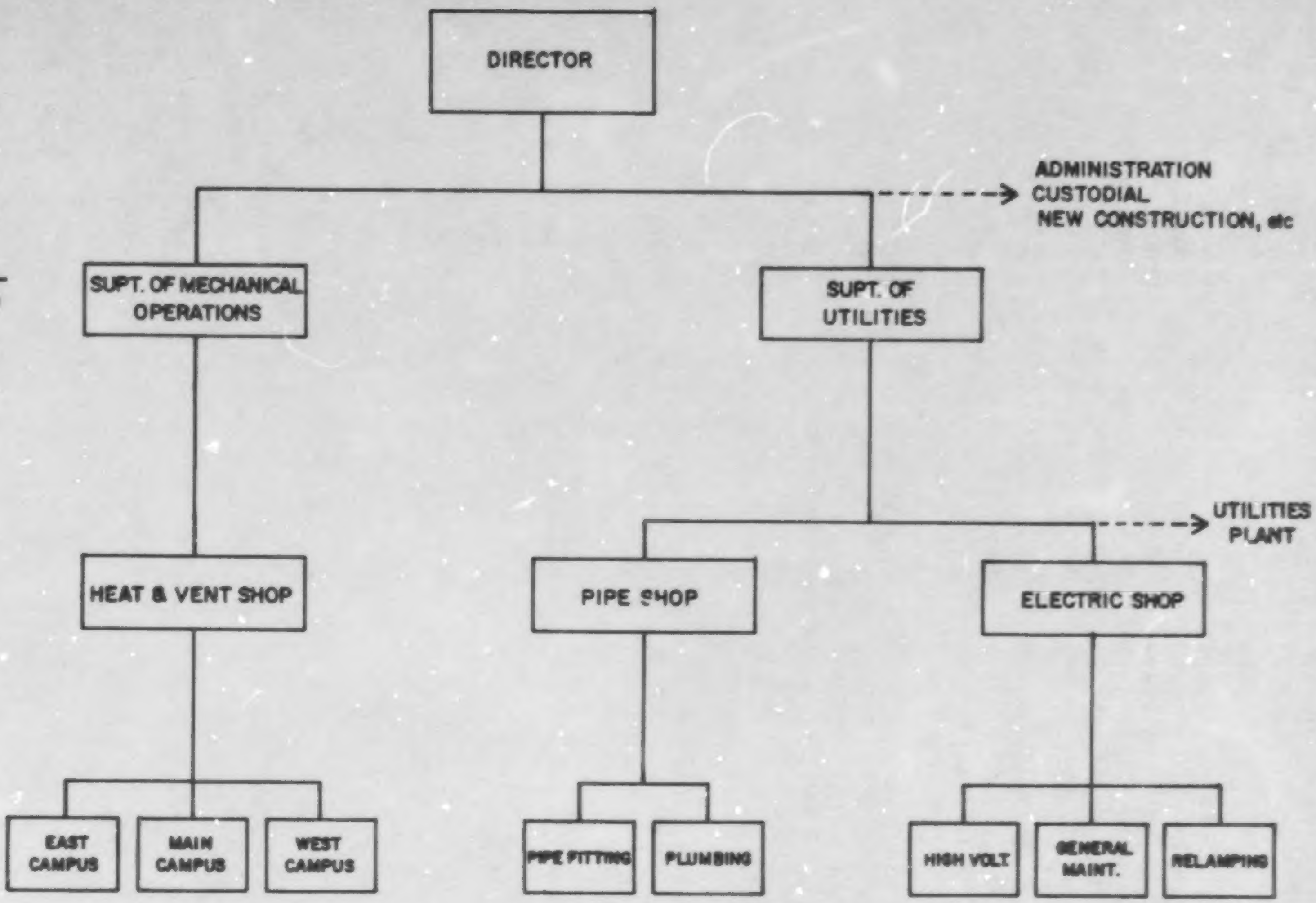
One area of expansion that we have ruled out for the present is the fire alarm system. While we now have our independent solid state/mechanical fire alarm system linked to FCS for detailed printout purposes, our safety office and insurers are still committed to a dedicated alarm system.

Summary

At MIT the introduction of an energy monitoring and control system (FCS) has changed the way we operate our physical plant department by providing a highly reliable means of controlling buildings and returning vital operating data. This in turn has freed up personnel resources to capitalize on the management opportunities provided by the operating data. Organizational structure and management emphasis have changed to respond to this situation. Cost avoidance levels attributed to maintenance efficiency are estimated at half of the cost avoidance realized from energy conservation and optimization use of FCS. A sizable potential for future operating savings exists through greater understanding and application of FCS capabilities.

Personnel

Supts.	2
Managers	0
Supervisors	10
Engr. Asst.	1
Clerical	2
Hourly	115
Total	130

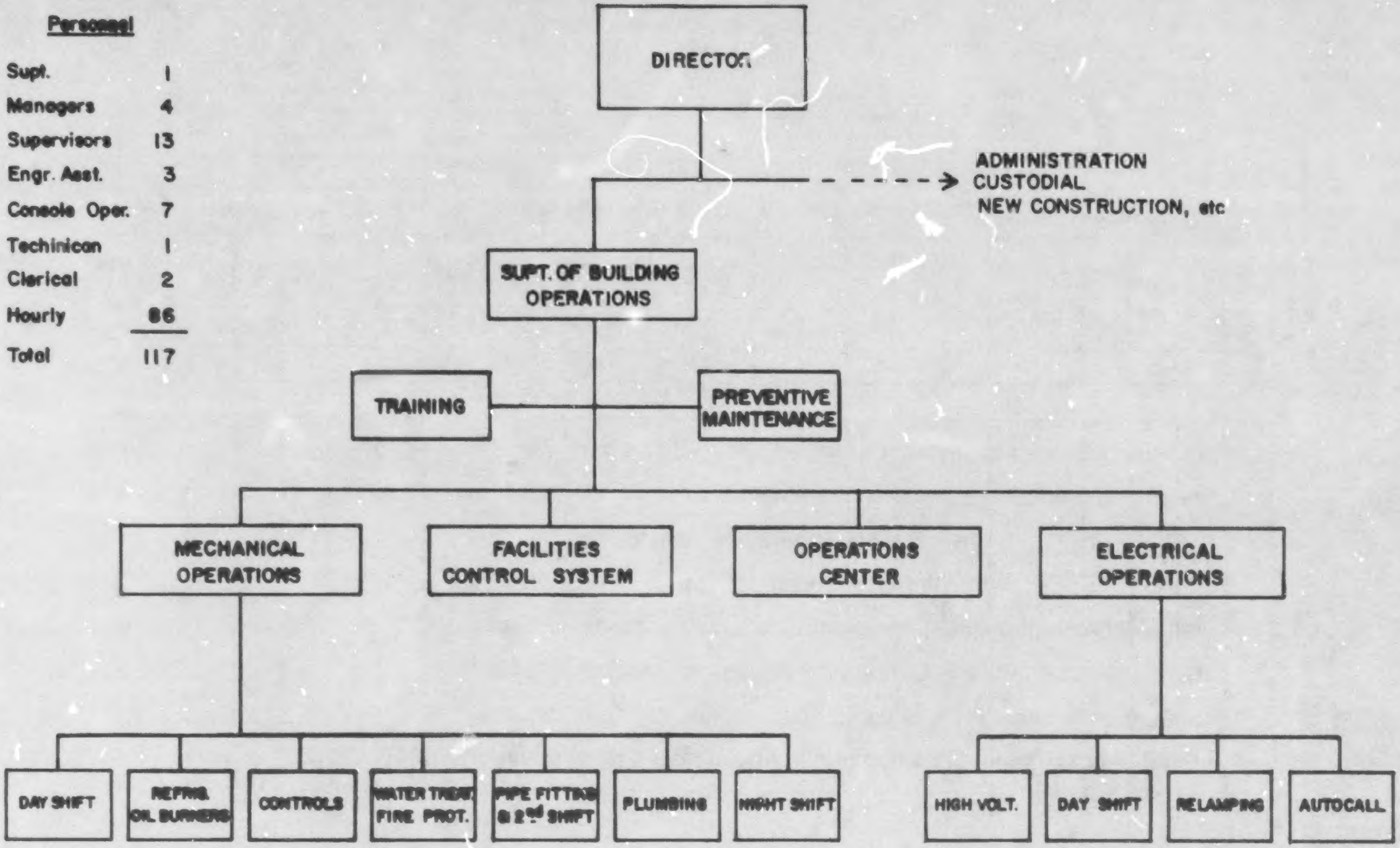

DIRECTOR
ADMINISTRATION
CUSTODIAL
NEW CONSTRUCTION, etc
SUPT. OF MECHANICAL OPERATIONS
SUPT. OF UTILITIES
UTILITIES PLANT
HEAT & VENT SHOP
PIPE SHOP
ELECTRIC SHOP
EAST CAMPUS
MAIN CAMPUS
WEST CAMPUS
PIPE FITTING
PLUMBING
HIGH VOLT
GENERAL MAINT.
RELAMPING

M.I.T. - Physical Plant
Mechanical / Electrical Operations & Maintenance
Prior to 1973
(Simplified for Presentation)

FIGURE 1

Personnel

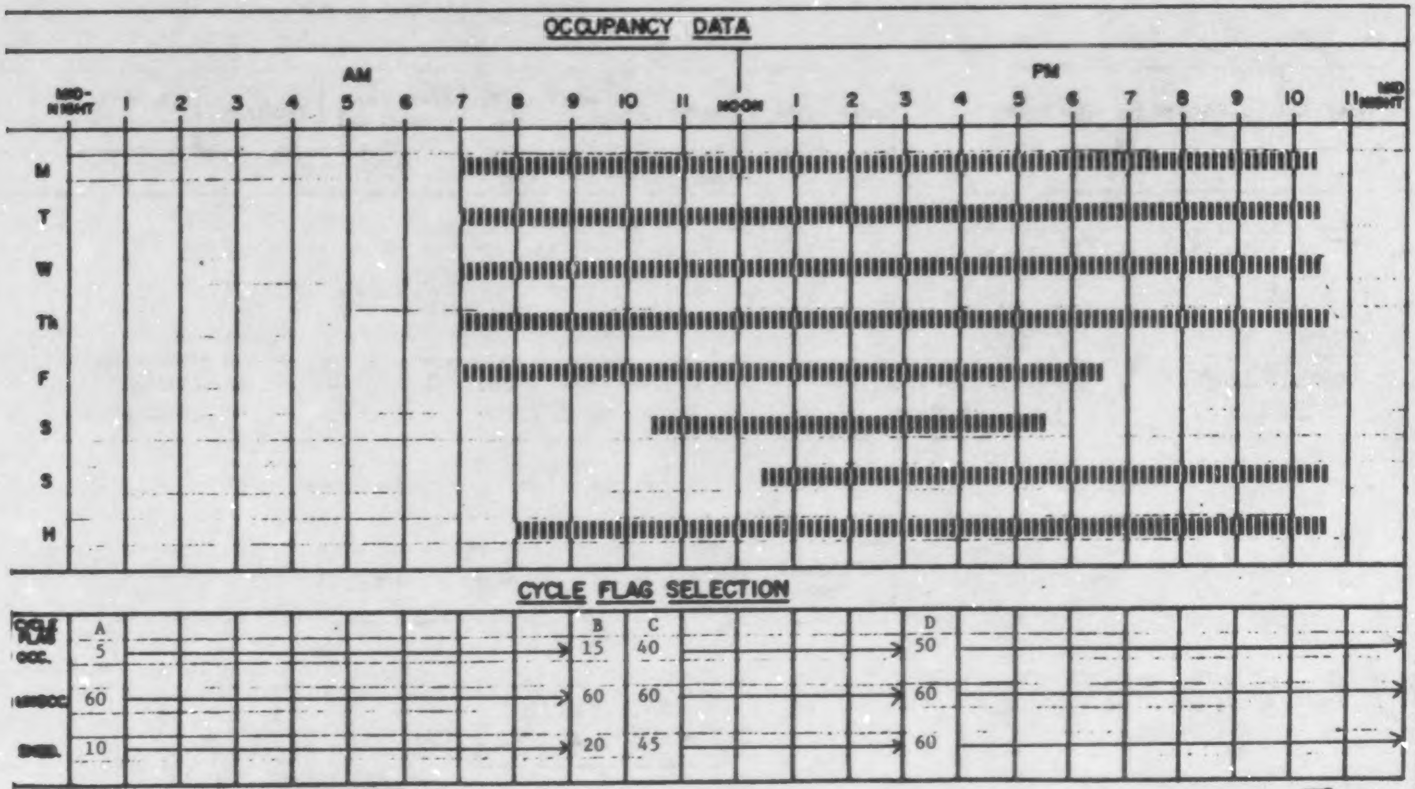
Supt.	1
Managers	4
Supervisors	13
Engr. Asst.	3
Console Oper.	7
Techinican	1
Clerical	2
Hourly	86
Total	117


DIRECTOR
ADMINISTRATION
CUSTODIAL
NEW CONSTRUCTION, etc
SUPT. OF BUILDING OPERATIONS
TRAINING
PREVENTIVE MAINTENANCE
MECHANICAL OPERATIONS
FACILITIES CONTROL SYSTEM
OPERATIONS CENTER
ELECTRICAL OPERATIONS
DAY SHIFT
REFRIG. OIL BURNERS
CONTROLS
WATER TREAT. FIRE PROT.
PIPE FITTING & 2nd SHIFT
PLUMBING
NIGHT SHIFT
HIGH VOLT.
DAY SHIFT
RELAMPING
AUTOCALL

M.I.T. - Physical Plant
Mechanical / Electrical Operations & Maintenance
1983
(Simplified for Presention)

FIGURE 2

BUILDING NO. 14 **SERVICE:** EAST WING FLOORS 1-3
SYSTEM NAME: AHI **SYSTEM NO:** 113



BUILDING NO: 14
SYSTEM NAME: AHI

CYCLE FLAG	MIN.OFF/HOUR		
	OCCUP.	UNOCC.	SHED.
A	5	60	10
B	15	60	20
C	40	60	45
D	50	60	60

CYCLE PERIOD: 1

	PREPARED BY:		ENTERED BY:	
	NAME	DATE	NAME	DATE
INITIAL	RWC	02/25/83	RWC	02/25/83
REV. A				
REV. B				
REV. C				

WINTER ☒
SUMMER ☐

FIGURE 3

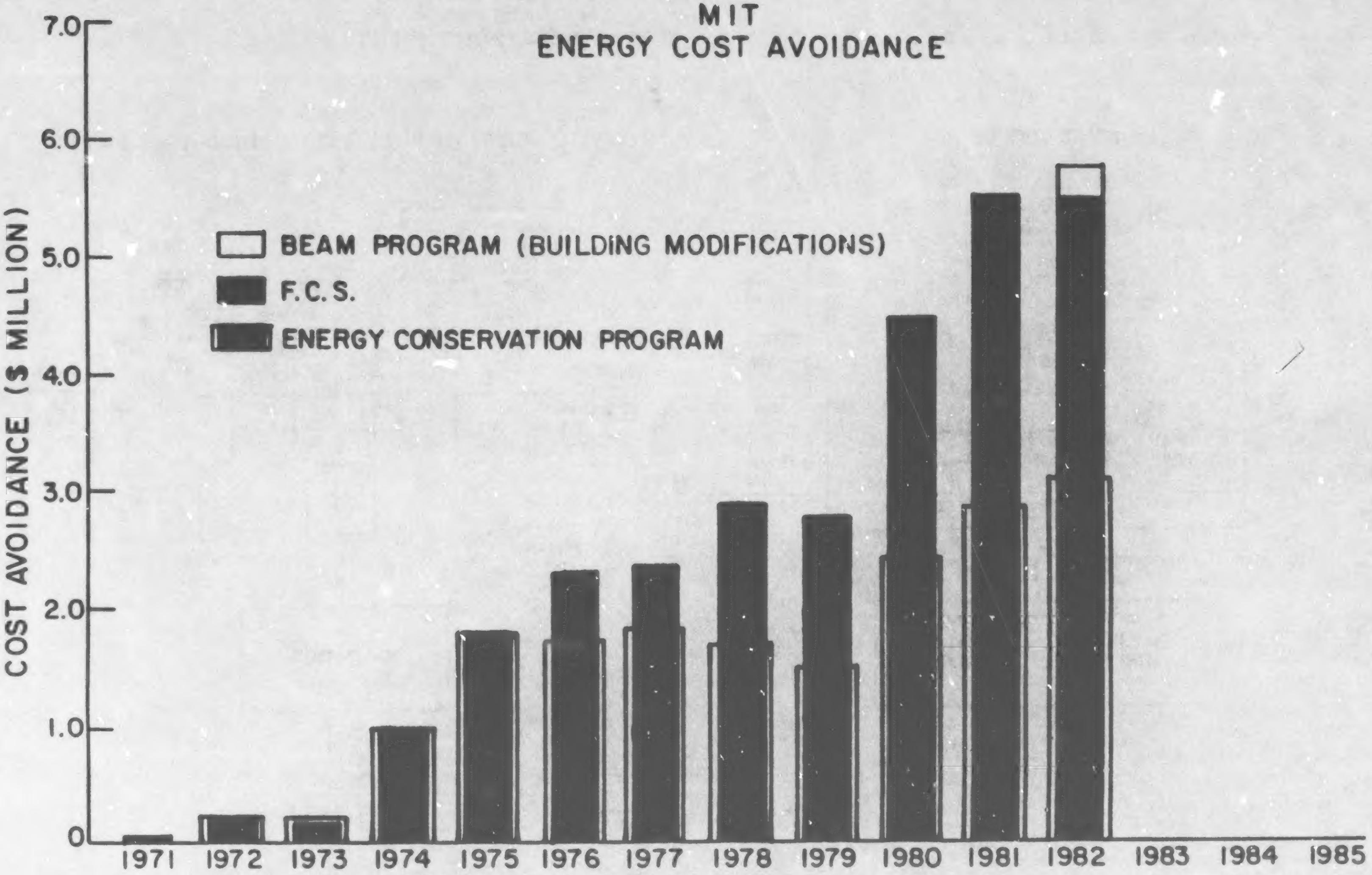
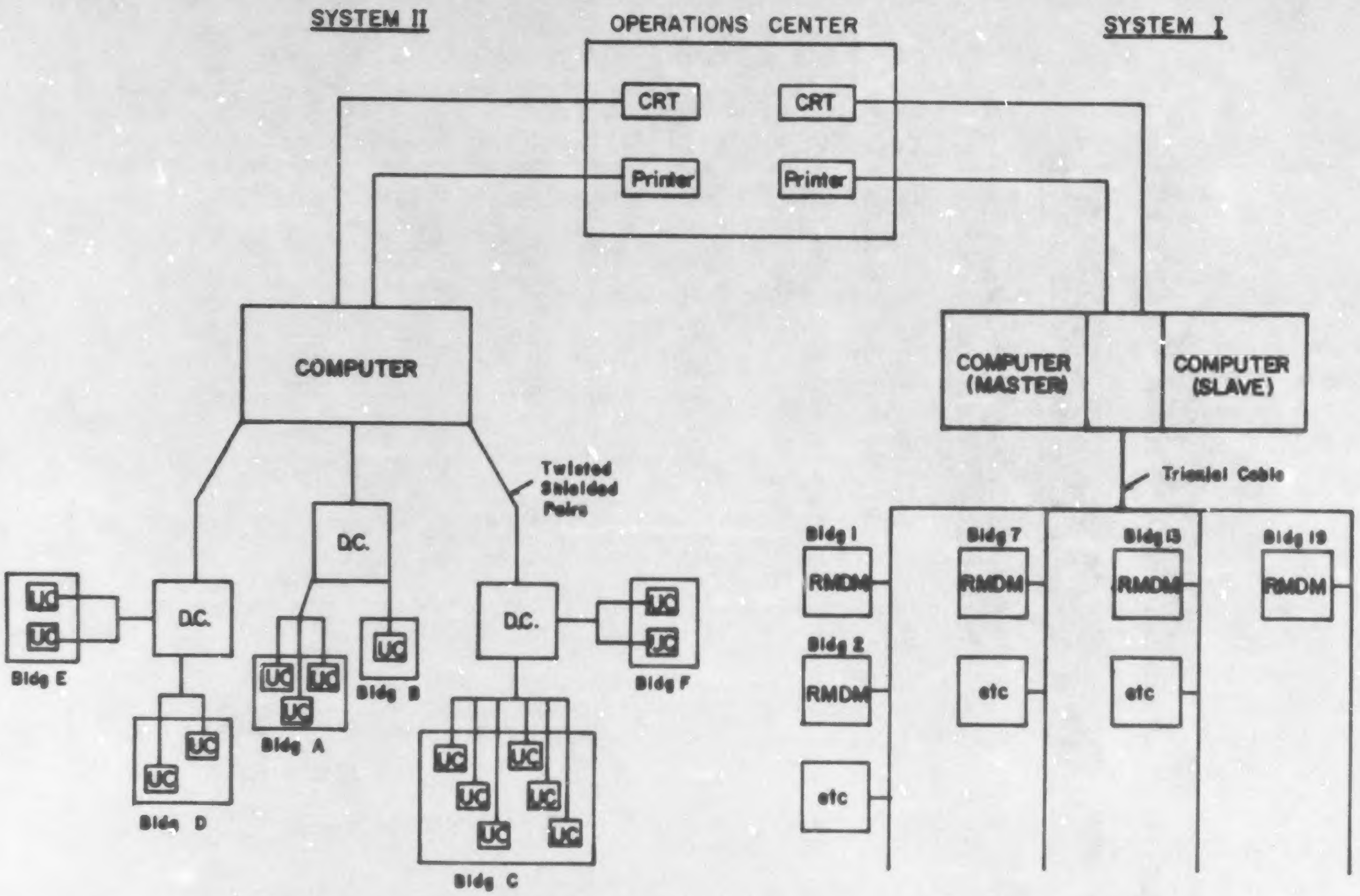

MIT
ENERGY COST AVOIDANCE
BEAM PROGRAM (BUILDING MODIFICATIONS)
F.C.S.
ENERGY CONSERVATION PROGRAM
COST AVOIDANCE ($ MILLION)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985

FIGURE 4


SYSTEM II
OPERATIONS CENTER
SYSTEM I
CRT
CRT
Printer
Printer
COMPUTER
COMPUTER (MASTER)
COMPUTER (SLAVE)
Twisted Shielded Pairs
Triaxial Cable
D.C.
D.C.
D.C.
UC
Bldg E
Bldg D
Bldg A
Bldg B
Bldg C
Bldg F
Bldg 1
Bldg 2
Bldg 7
Bldg 13
Bldg 19
RMDM
etc

44 UNIT CONTROLLERS IN 16 BUILDINGS

34 BUILDINGS

CRT - Cathode Ray Tube Console
DC - Data Concentrator
RMDM - Remote Microprocessor Data Management Unit
UC - Unit Controller

M.I.T. - Physical Plant
Facilities Control Systems (FCS) - 1983

FIGURE 5

Tuesday, July 12

LOUISVILLE,
KENTUCKY

APPA
'83

Getting Through to People

By Edwin B. Feldman
Service Engineering Associates, Inc.

One would think that the communication of a thought or an instruction to another person would be a simple thing. After all, we have words to use (both spoken and written), drawings, diagrams, and other means. And yet, communication with another person is one of the most difficult problems which any human being faces, and certainly one of the most difficult problems faced by the Physical Plant Administrator.

Perhaps the problem can be seen clearly when one enumerates the various obstacles to communication. Here are just some of them:

1. Emotions are a barrier to communication. When a person is angry, fearful, or exhibiting any other strong emotion, it is difficult for him to comprehend what the other person is saying -- even if the other person did not cause the emotions to begin with.
2. If the communication involves an impending change, then the inherent resistance to that change, which most people have, will be a handicap.
3. There is the tendency, simply, not to hear the other person. Sometimes this is because one is lost in his own thoughts. It is like a person telling someone a funny story; the second person does not really listen, because he is preparing his funny story to tell to the first person; and when that chance comes, the first person, in turn, is preparing his next story as soon as the second person finishes!
4. Then, there is the question of wishful hearing; we tend to hear the things which we want to hear, even if some other meaning was conveyed. A supervisor telling a worker about a problem the worker has, but also complimenting the worker, may have the compliment remembered but all thought of the problem forgotten.
5. In trying to communicate with another person, sometimes we make assumptions about that person's knowledge or opinion which are unwarranted. The information which we are trying to pass on, then, "doesn't fit".
6. In some people, there is the simple desire to please. In the history of polar exploration, the problem arose with communicating with the Eskimos. The natives were so anxious to please, that they typically gave an answer which they thought that the questioner wanted to hear. For example, the Franklin relief party would ask an Eskimo, "Have you seen the Franklin expedition?". The Eskimo, never having heard of the Franklin expedition, would answer "Yes" because that is what the questioner hoped to hear.

7. Some people will not risk placing reasonable trust in others, and thus color everything with suspicion.

8. As is well known to everyone, words mean different things to different people. A word has a particular meaning for an individual because of his education, background, experiences, reading, etc. That word does not necessarily convey the same meaning to someone else.

9. One of the strongest roadblocks to communication is prejudice, of which, unfortunately, there are many varieties. The individual is not aware of most of his own prejudices.

10. Viewpoints can differ markedly. There is an old story told about a newspaper reporter questioning the morale of the workers in a factory. When talking to the union official, the reporter was told that the workers had great morale, since they were about to strike; but when the reporter talked to the plant manager, he was told that the workers had very bad morale, since they were about to strike!

11. Some people just "tune out", so that there is no communication at all. Another occurence in the history of exploration concerned Captain Cook's expedition to Australia. When his vessel first entered Botany Bay, the aborigines on the shore had never seen a boat of any kind, much less a full-rigged vessel in full sail; they had never seen a longboat filled with men; they had never seen men dressed in uniforms (or dressed at all, for that matter); and had never seen the weapons and other paraphernalia which the sailors carried. The response of the aborigines was to ignore it all, as if it were a figment of their imagination.

The problem of communication is very simply and directly demonstrated with the parlor game where one person makes a statement to another person, and the second person repeats it to a third, etc. By the time the remark "goes around the circle", the statement which the last person makes to the first is entirely different.

Listening

If you want a good example of the difficulty of listening -- as if an example were necessary -- offer to say the following fourteen words to someone, and see if he can repeat them to you word for word:

"Good morning, sir," said Eve to Adam.
"Good morning, madam," to her said Adam.

Not one person in fifty is able to repeat those simple words, that exchange of greetings. You will find that most people are able to give you the first half, but in concentrating on that, they miss the second half.

How do we improve our listening? There are a number of possibilities.

- You can develop listening in others by asking them a series of questions, beginning with very easily answered questions, and building up to those which are more difficult.

- Attempt to get people to tell you how they feel; this emotional release is helpful in preparing them to listen.
- For yourself, attempt to listen unemotionally; and try to separate ideas from emotions.
- Try to listen between the words; as some people say, try to listen to what is not being said. You are looking for implications.
- Be courteous in your listening. Forgive people for rambling or making digressions; try to carry the thread of their thinking.
- Give the speaker an evidence of your listening. For example, keep eye contact; make notes of what is being said; show by your body language that you have a studious attitude; nod approval at the proper time; smile or laugh when appropriate.

About Emotions

Although emotions can inhibit listening and communication under certain conditions, under others they can be helpful. Emotions can motivate expression, and can lead to an animation which is easy to follow and interesting to hear.

Further, the emotion may hint at what the person is feeling, in addition to what he may be saying. It takes a good deal of skill, however, to get the true impact of emotions.

With most people, emotions are stronger than logic or reason, and sometimes we must appeal to both to gain our point. In helping people to understand us, we may wish to point out to them the problem which they may have with their emotions, but, of course, don't criticize their emotions.

A particularly powerful form of communication is touching, such as the hand on the shoulder, or, more frequently, the handshake. Overdoing touching, however, can act as a threat to some people.

Encourage people to communicate. Be courteous to them when they wish to speak. Simply, make communication enjoyable; show appreciation for their words, and allow them to build their ego and self-image through their communication with you.

Feedback

The true test of communication is feedback. If you really want to know whether a person has understood what you have said (or written), tell him to repeat it to you. It will be no surprise to you that a large percentage of this "feedback" will be in error, and this will give you an opportunity to correct that error.

The more people through whom a communication passes, the more distortion there will be; there should be feedback at every stage. Obviously, this problem in communication through various levels is one of the reasons for which there is always the desire to simplify the organization, to put a smaller number of people in the chain between the lowest and the highest points.

Sometimes we need silence to communicate, as paradoxical as this may sound. After many attempts to make a point with a person, it may be desirable to have no communication for a time, to give that person the chance to reflect on what has happened. Then, a simple communication may obtain the desired result.

Since every human being is different from every other, then our communications will be unique. An interesting exercise involves the writing of a headline for a simple story. Take the following narrative, for example:

> A five-year-old boy from Jonestown named Joe Jackson was riding his bicycle toward Smithville. As he was passing the airport, he was hit by a truck. An airport worker from Houston named Bob Harris saw this, rushed over to the boy, and, because of his first aid training, was able to save his life.

If you ask a number of people to write a headline, a maximum of six words in length, to describe the above story, you will probably get as many different headlines as there are people. And yet, each person writing the headline heard the same story, or even saw it in print. The headline which each person writes will be evidence of his background, education, experience, viewpoint, emotions, etc. But every one of the headlines may be an effective communication.

It is an exciting thing to find someone with whom we can communicate simply and directly; but it is a very rewarding thing to be able to communicate with people who have communication problems; and we are able to do this by applying understanding, patience, and knowledge.

Biomass Fuels to Heat and Cool a University Campus

By Paul T. Spelman, P.E.
Progressive Engineering Consultants
of Grand Rapids, Inc.

The utilization of campus generated waste paper and locally produced wood chips or wood product residue as fuel for boilers offers colleges and universities an opportunity to save two of every three dollars they now spend purchasing natural gas or oil.

Benefits of Biomass Systems

The benefits that are realized when a facility converts to a biomass fuel system are listed below. Each will be described in detail in sections that follow.

- Fuel is locally produced.
- Fuel money acts as an economic stimulant to the local economy.
- The forest resource is enhanced.
- Fuel harvesting can provide a laboratory for the school's Forestry Department.
- The facility saves money.
- Where coal or oil are replaced, "acid rain" is reduced.
- Landfill requirements are reduced.
- The residue or ash is an agricultural fertilizer.

Fuel is locally produced. The fuel for a biomass system is wood and paper. The wood is procured in the form of whole tree chips or as sawdust and chips from local sawmills and wood processing plants. The market area is generally limited to a 70 mile radius.

The biomass burning systems can burn up to 15 percent paper (based upon Btu equivalents). The paper must be shredded and mixed with the wood so that a homogeneous mixture is fed into the burner. This is done to maintain a uniform moisture content which, in turn, reduces the potential of smoke from the stack.

A fuel supply that is local is controllable. While inclement weather can cause minor delays, the supply is not at the mercy of foreign producers, pipe liners or other disruptive forces beyond the facility's control.

Fuel money stimulates the local economy. This represents one of the major benefits of a biomass system. The fuel money stays in the local economy; it creates economic activity equal to four or five times the dollars spent. It provides jobs.

The fuel money helps achieve national energy independence while, at the same time, keeping dollars from the hands of nations who would use them to the detriment of the United States.

The forest resource is enhanced. The major concern that has been expressed in Michigan communities where biomass systems are being built is that the woods will be "raped." Some of the people still have visions of the mile after mile of pine stumps left when loggers felled the great white pine forests of the state. It has been necessary to assure them that the opposite is true. The procurement of wood from the forests must be on a managed basis. Control must be exercised so that the harvesting operation actually enhances and improves the forest resource.

It may appear to be a contradiction saying that the wood is to be removed, yet the resource is to be improved. The basic harvesting operation will remove approximately 40 percent of the standing or fallen wood. The trees that can grow to saw logs or veneer logs are marked. All of the other dead, dying, diseased, crooked and non-commercial growing stock is removed. Trees that have the potential for commercial timber use are left. This thinning process is repeated at two more 10-year intervals. Initial removals and those at the thinning intervals will equal 40 to 50 tons per acre. After the final thinning, 10 to 15 commercially valuable trees will remain for harvesting as timber.

If one thinks about it, the present method of removing timber in most of the country is the reverse of good management. The big trees are felled and removed; all of the "junk" trees are left to grow. The biomass that the sun creates goes into the non-commercial stock because the potentially valuable trees are cut as soon as they emerge. This method of harvesting reduces the quality of the resource and helps create all of the ills that go along with a dwindling resource base.

Provide a laboratory for the Forestry Department. The managing of the forest resource is basic to instruction given by the Forestry Departments of large universities. A university with 15,000 students will require approximately 45,000 tons of wood chips to meet its heating and cooling requirements. It will take about 12,000 acres of managed forest land to meet this requirement. This offers an unparalleled opportunity for the Forestry Department to contact landowners, make management plans for them, then hire and control the chippers who will do the harvesting. A living laboratory can be created where that which is being taught can be practiced.

The facility saves money. This is the bottom line. Central Michigan University in Mt. Pleasant, Michigan is building a wood burning facility that will cost $3,500,000. The projected wood fuel costs over the next 10 years are $11,000,000, while the projected natural gas purchase price over the same 10 years would have been $37,000,000. A report to Ferris State College in Big Rapids, Michigan showed that a proposed $3,500,000 facility would save $25,000,000 over the next 10 years. Another study for Andrews University in Berrien Springs, Michigan showed that a $319,000 investment would result in a saving of $6,930,000 over the next 10 years.

The savings shown for the three facilities in Michigan can be fairly typical for sections of the country that have 20 percent or more of their land area in woods.

The savings should hold for most areas of the country. In the north, the winter loads will be the heaviest; in the south, the need for absorption chillers for cooling will put the greatest loads in the summer.

The potential exists to add cogenerating systems to those being built. With both heating and cooling loads, the systems will have relatively uniform loads. Cogeneration can further enhance the savings to be realized.

"Acid rain" can be reduced. Wood and paper contain no sulfur. Their burning is controlled in such a way that there are very few nitrogen compounds created. The gas exiting the stacks will add no materials that will later fall in the form of "acid rain."

"Acid rain" is a very serious problem in all parts of this country and Canada where the soils do not have a natural limestone neutralizer. The increase in pH is creating a very dangerous situation that can affect our forests, our lakes, and our farms. It can only be stopped by either stopping the burning of sulfur containing coal and oil, or by removing the sulfur compounds from the boiler stack gases. Every bit removed is that much less that falls on ecologically fragile areas of our country and Canada.

Landfill requirements are reduced. The potential for burning the paper wastes generated on campus will save money, in that the fuel itself will be free, while at the same time the costs of hauling to and disposal in a landfill are eliminated.

Paper waste has an energy content of 8,000 Btu's a pound. This compares with whole tree chips at 45 percent moisture that contain 4,200 Btu's a pound. Whole tree chips in Michigan in 1983 can be purchased for $16 a ton. Every ton of paper that can be burned is equivalent to saving the cost of two tons of wood chips.

Landfill requirements for the community will be reduced. The wastes coming from campuses contain approximately 90 percent paper. By burning the paper, the fill volume will be reduced and the life of the landfill extended.

Residue or ash is an agricultural fertilizer. The residue or ash from a wood and paper burning facility is an agricultural fertilizer. It is a very good source of potash. As a result, it is in demand by local farmers. It can be used for the same purpose by the grounds personnel of the educational facilities. The incorporation of the ash from the burning processes into the soil represents the final recycling of these renewable resources.

Burning Systems

The wood burning systems available are either a gasification or pyrolytic system, or a direct burning system. Both require the same support equipment.

Gasification or pyrolysis. The gasification or pyrolytic systems turn the biomass material into a low Btu gas. The gas is burned in a burner that is close coupled to the pyrolysis unit or is piped to a burner similar to natural gas. The unit showing the most promise is the close coupled "wet-cell" type. A 60 million Btu output unit of this type will be installed on the campus of Central Michigan University in Mt. Pleasant, Michigan, where it will provide the thermal energy to heat and cool the campus. Units of this type range in output size from 20,000 to 100,000 Btu's an hour.

The wet-cell burner (shown in Figure 1) could be considered a hot gas generator in that the fuel is burned outside the boiler and the hot gases then ducted into the boiler's fire box. The boiler, in effect, becomes a waste heat recovery boiler. This type of system does not require any changes in the existing boiler plant, provided there is space for the refractory lined duct to be run to the boiler.

There are a number of other pyrolysis systems that can fuel boilers with outputs ranging from one million to 35 million Btu's per hour. The solid fuels burner manufactured in the Chicago area is one of the better ones.

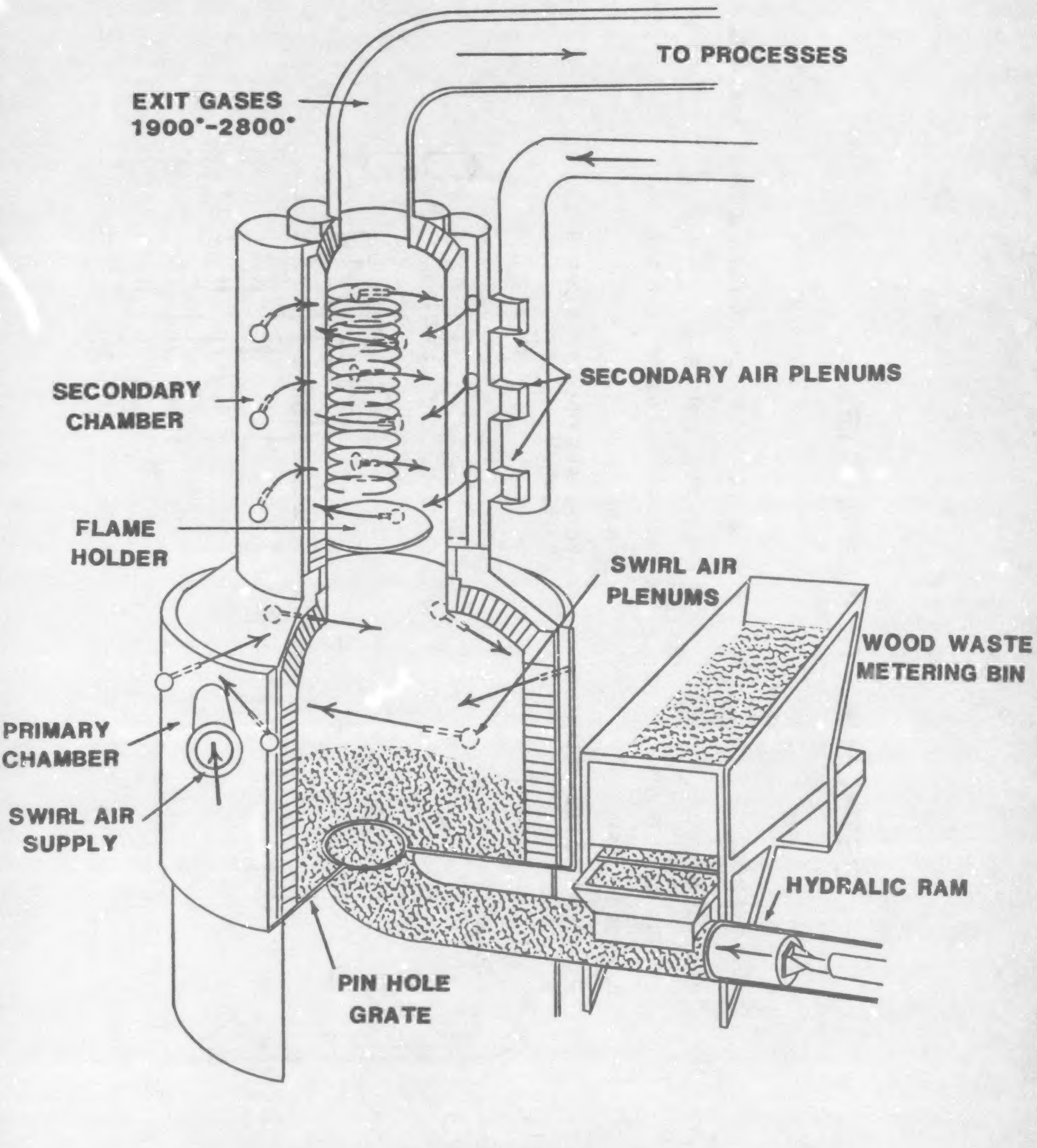
The pyrolytic systems are versatile. They have turndown ratios of four to one, and can burn material with moistures up to 60 percent. They require a reasonable sized chip; they will not work if the fuel has a high percentage of fine sander type dust.

Direct burning. This type of burning is stoichiometric. The material is burned on the boiler grate or in suspension in the fire box. Sufficient oxygen is supplied to complete combustion. The fuel is generally blown into the fire box with the heavy chips falling onto the pin grate bottom and burning there, while the fine material burns in suspension. Systems of this type can be used to retrofit existing boilers that have high fire boxes.

The direct burning systems can be used for boilers having outputs ranging from one million to 35 million Btu's. They have a four to one turndown and can burn fuel with moisture contents up to 50 percent. When using a gas or oil boiler, it will have to be derated approximately 25 percent. Figure 2 shows a typical direct burning boiler system.

The wood burning systems described above can be used to fire boilers ranging from hot water to steam boilers generating 750°F steam at pressures

FIGURE 1


TO PROCESSES
EXIT GASES 1900°-2800°
SECONDARY AIR PLENUMS
SECONDARY CHAMBER
FLAME HOLDER
SWIRL AIR PLENUMS
WOOD WASTE METERING BIN
PRIMARY CHAMBER
SWIRL AIR SUPPLY
HYDRALIC RAM
PIN HOLE GRATE

WET CELL BURNER

FIGURE 2

BETHLEHEM BOILER SYSTEM

A. BLOW HOG

B. CYCLONE

C. STORAGE SILO WITH UNLOADER

D. FUEL METERING

E. PNEUMATIC FUEL TRANSPORT

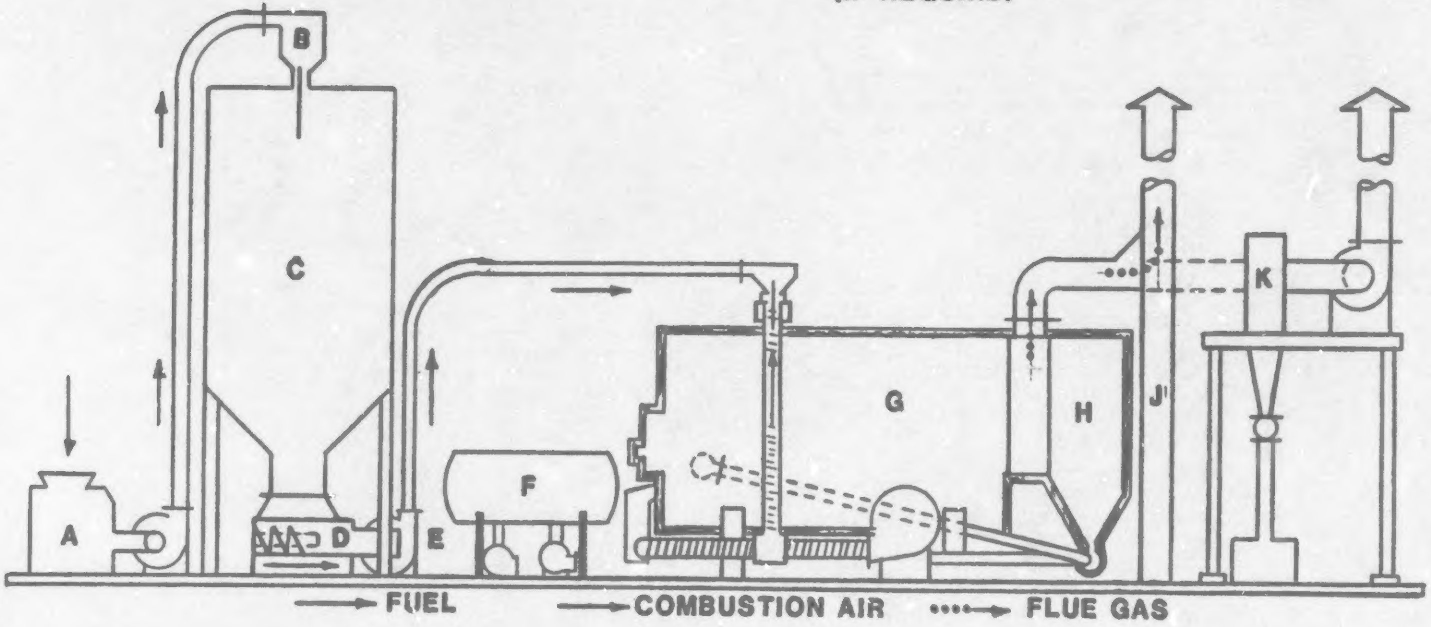
F. FEED WATER SYSTEM SIMPLEX (DUPLEX AVALABLE)

G. MULTI-FUEL BOILER

H. PRIMARY POLLUTION CONTROL

J. STACK

K. SECONDARY POLLUTION CONTROL (IF REQUIRD)


B
C
A
D
E
F
G
H
J
K
→ FUEL
→ COMBUSTION AIR
••••→ FLUE GAS

up to 900 pounds per square inch (psi). Wood fired boilers can do all that any other fueled boiler can do. They have a saving grace in that the ash is a fertilizer that is in demand by local farmers.

The Central Michigan University System

Central Michigan University, a 15,000 student university in Mt. Pleasant, Michigan, has a facility in engineering design that will heat and cool the campus using wood as its primary fuel. The new plant will be a pyrolytic unit with the fuel burned outside the boilers and the hot gas ducted into two 75,000 pound per hour Wickes boilers. The existing boiler plant will not be disturbed since the refractory lined ducts will be in the basement and will enter the existing boilers through the bottom floor.

The proposed facility is shown in Figure 3.

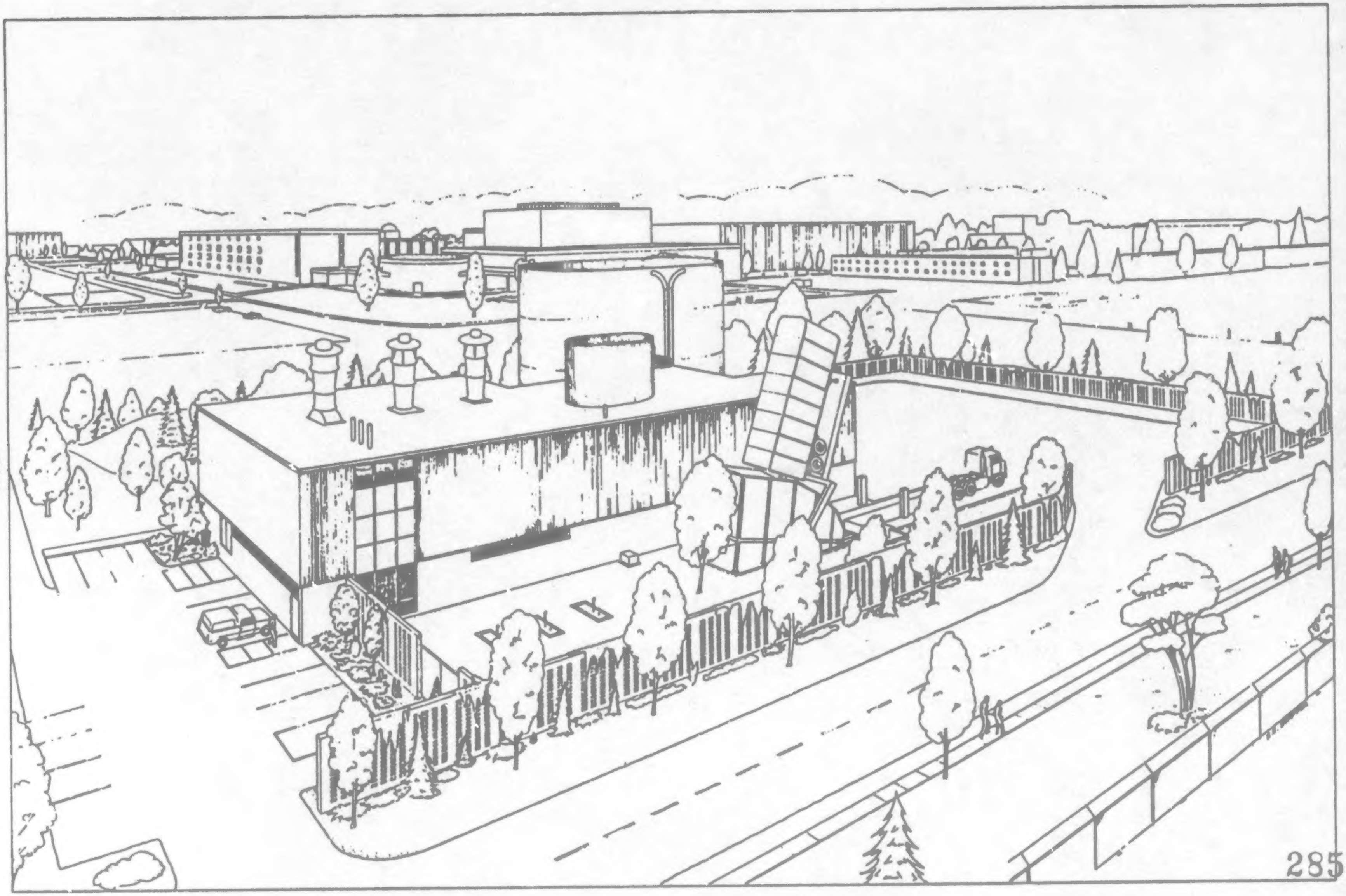
The entire system will consist of the following:

- A truck scale to weigh trucks in and out.
- A truck dumper which will lift only the trailer.
- A receiving hopper and conveyor to a disc screen.
- A magnet over the conveyor to remove tramp iron.
- A disc screen with oversized material going to a small "hog."
- Hog to reduce oversized material.
- Blower to move material to silos.
- Two 30' diameter by 75' high concrete silos.
- Blower to take material from silos to the burner feed box.
- 60,000,000 Btu/hour pyrolytic burner.
- Ash removal conveyor.
- Refractory duct to existing boilers.
- Building to house equipment.

The estimated cost of the proposed system is $3,500,000. The system will burn approximately 45,000 tons of wood chips a year. The material will be obtained from managed forests within a 25 mile radius of the campus.

The paper burning system will not be installed at this time. Space adjacent to the silos has been set aside to house a paper shredding machine and a blower to put the paper into the silo at the same time the wood fuel is entering.

FIGURE 3



C.M.U. Power Plant Additions

Table 1
Central Michigan University
Power Plant Conversion to Wood

Capital Cost

Description	Equipment Cost	Installation	Total
Truck Scale	$ 19,000.00	$ 13,500.00	$ 32,500.00
Truck Dump & Hopper	85,000.00	40,000.00	125,000.00
Pneumatic Conveying	175,000.00	87,000.00	262,000.00
Storage Silos	180,000.00	70,000.00	250,000.00
Wet Cell	986,800.00	422,200.00	1,409,000.00
Breeching	95,000.00	55,500.00	150,500.00
Mechanical and Electrical	135,500.00	134,500.00	270,000.00
Building	70,000.00	60,000.00	130,000.00
Excavation and Landscaping	40,000.00	90,000.00	130,000.00
		Sub-total	$2,759,000.00
		Contingency	275,000.00
			$3,034,000.00
		Architectural Treatment	240,000.00
		Engineering	226,000.00
			$3,500,000.00

Table 2
Central Michigan University
Power Plant Conversion to Wood

Projected Savings

Year	Annual % of Increase	Univ. Cost of Nat Gas	Cost of Wood	Operating** Expenses	Nat Gas Standby Cost	Net Savings
1982	Base Year	$ 1,560,920	--	--	--	--
1983	20	1,873,100	--	--	--	--
1984	20	2,247,720	764,580	417,860	47,000	1,018,280
1985	20	2,697,260	825,750	451,290	47,000	1,373,220
1986	12	3,020,940	891,810	487,390	47,000	1,594,740
1987	10	3,323,030	963,150	526,380	47,000	1,786,500
1988	8	3,588,870	1,040,210	568,490	47,000	1,933,170
1989	8	3,875,980	1,123,420	613,970	47,000	2,091,590
1990	8	4,186,060	1,213,300	663,090	47,000	2,262,670
1991	8	4,520,940	1,310,360	716,140	47,000	2,447,440
1992	8	4,882,620	1,415,190	773,430	47,000	2,647,000
1993	8	5,273,230	1,528,410	835,300	47,000	2,862,520
Total	--	$37,616,650	$11,076,180*	6,053,340	470,000	20,017,130

Based on replacing 325,191 MCF of natural gas with 43,700 tons of wood.

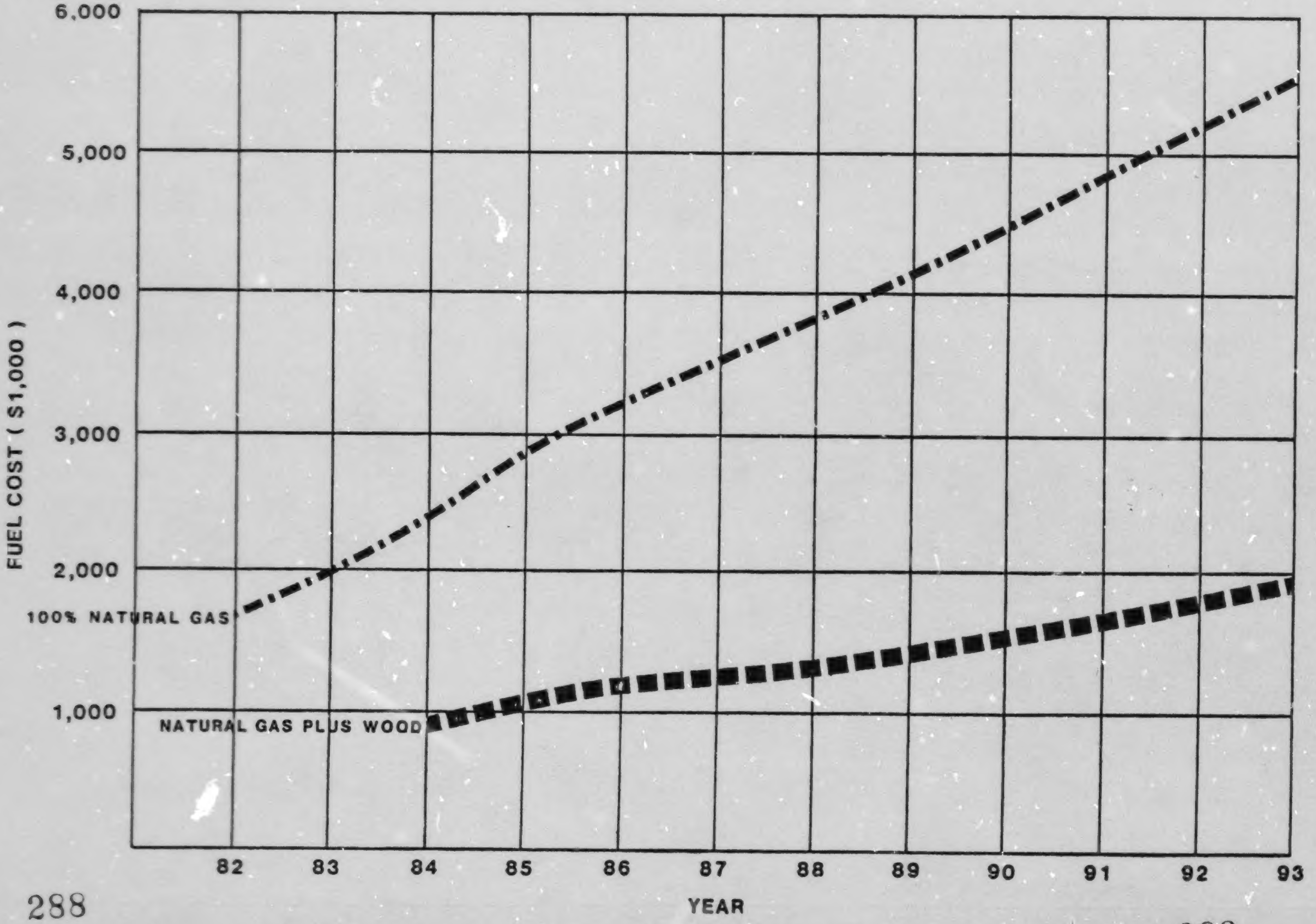
* Based on 8% per year escalation.

** Operating expense includes annual cost for seven additional men, electrical costs for operating 400 additional horsepower, and cost of gas during seven-day annual shutdown of wood burner. Operating expenses are escalated 8% per year.

FIGURE 4

ESTIMATED ANNUAL FUEL COST FOR C.M.U.

BASE YEAR 1982



Tables 1 and 2, and Figure 4 are the economic analysis of the proposed facility. (These and the other figures are taken from a presentation being made by CMU.) A review of these figures shows the financial benefit that will accrue to both the university and the local community. The university will save $20,000,000 over 10 years, while the local community will receive $11,000,000 in fuel money.

The benefits that are shown here for Central Michigan University and for the Mt. Pleasant community can be duplicated in a number of similar facilities in the United States and Canada. All that is needed is:

- A cooperative administration.
- The courage to be innovative.
- The willingness to spend time to assure resource availability.
- The money to hire a competent consultant to put the package together.

The reality of the present is that wood and waste paper is available to most as a fuel to heat and cool the campuses of North America. It will stay in the realm of the potential until a commitment is made to utilize them.

Energy Conservation from Waste-Cogeneration Potential

by Richard B. Robertson, P.E., Executive Vice President
Bovay Engineers, Inc.

You have just heard a presentation of the benefits of energy conversion from biomass fuels for use in heating and cooling a campus. In that case the biomass fuel was wood waste supplemented by coal as required.

A number of refuse to energy facilities are being installed currently or are under design primarily by municipalities. These generally utilize municipal and industrial solid waste as fuel and are used to generate steam for various uses. For a medium-sized city of 100,000 population the municipal and industrial solid waste would generally amount to 200 to 250 tons per day. Depending upon the makeup of this waste, it would generally have a heating value of around 4,000 B.T.U.'s per pound. That amount of energy will produce between 40 and 50,000 pounds of steam per hour at whatever pressure desired and that steam then can be used for sale to industry, for heating and cooling, for generation of electrical energy or sometimes a combination of all three.

A large university and its immediate surroundings will generally produce about 10 percent of the above waste or 20 to 25 tons per day. This may be predominantly paper waste in which case the heating value is higher. This could be used to produce about 8,000 pounds of steam per hour average for heating and cooling. The value of this waste at an energy value of $5.00 per million B.T.U.'s would be about $1,250 per day or over $300,000 per year.

That amount of waste, of course, is not sufficient to meet the demands of a large university and it would need to be supplemented by other fuels such as natural gas, fuel oil, coal or other biomass fuels.

Packaged equipment is available for municipal waste conversion in capacities up to 100 tons per day. For larger tonnages, multiple units can be used. Also custom designed and built units are available for any capacity desired.

Most campuses have a steam requirement larger than the above if they utilize a central plan for heating and/or cooling. In order to illustrate the uses which can be made of this energy obtained from waste conversion plus supplemental fuel in the most efficient way, I am going to present examples of cogeneration cycles based on a campus need for 100,000 pounds per hour of steam. Multiples of this figure can then be used to apply the illustrations to your own campus and its particular steam requirements.

If the fuel to be utilized is a solid fuel, supplementing a conversion of municipal waste, then the primary cycle for cogeneration from this fuel would be through the generation of high pressure steam which could be utilized to drive a steam turbine generator producing electricity and extracting steam at a lower pressure for campus heating and chilling. In order to provide flexibility the turbine generator should also be of the condensing type with a condenser and cooling tower which provides the ability to vary the electrical load and the heating and chilling load daily and seasonally as required. The 100,000 pound per hour of low pressure steam requirement would permit the selection of a 5,000 KW turbine generator. Normal operation would provide for most of the steam to be extracted at a pressure of 20 psig with a small amount of steam being condensed in order to cool the latter stages of the condensing turbine. The after stages of the turbine and the condenser should be sized, however, to handle sufficient steam flow when operating straight condensing (with no extraction) as to utilize the full capacity of the generator. This would be approximately 50,000 pounds per hour, if the turbine steam pressure and temperature were selected to be 600 psig 750° Farenheit. Higher pressures, of course, are possible but are not generally recommended for campus usage.

Figure 1 shows a typical flow sheet for a boiler steam turbine generator operation such as I have just described with the steam produced at high pressure and piped to the throttle of the steam turbine with most of the steam then extracted at low pressure for use in the campus heating and cooling system.

Figure 2 is the same flow chart but with the quantities installed as discussed above, indicating that the boiler is generating 100,000 lbs/hr. of steam at 600 psig, 750°F. That amount of steam at that pressure will drive a steam turbine generator to produce about 5,000 KW of electric power while extracting the steam at low pressure for the campus heating and cooling system. For simplicity in these charts, I have indicated the same quantity of steam generated by the boiler is extracted at low pressure whereas actually there would be a small percentage of cooling steam required passing through the latter stages of the turbine and condensed in the condenser. Also not shown are the other auxiliaries such as cooling tower, pumps, etc.

In order to utilize this co-generation system with the conversion of waste materials, the steam generator would be selected to be of a type to properly reduce the waste materials to ashes and produce the quantity of steam as indicated above. Supplementing this would be either a solid fuel such as coal or wood waste. Or, of course, the boiler could also be designed to utilize natural gas or fuel oil as supplemental fuel. The fuel would be required to produce 150,000,000 BTU's per hour.

Before going into the costs and revenues for the above, I want to present other types of co-generation systems that can be used on a campus. This next figure is a typical flow sheet for a combustion turbine heat recovery boiler wherein the combustion turbine drives a generator to produce electric power and exhausts into a heat recovery boiler to produce low pressure steam which can then be used for heating or cooling on campus. The fuel in this case is limited to either natural gas or fuel oil, preferably No. 2 grade. Other fuels can be burned in the combustion turbine, but their affect on the maintenance costs makes them undesirable.

Figure 4 shows this same flow sheet, but with quantities added. The amount of low pressure steam is still assumed to be 100,000 lbs/hr. at 20 psig. A combustion turbine to produce this amount of exhaust heat could drive a generator producing about 20,000 KW of electricity and would have a fuel requirement of 250,000,000 Btu's per hour.

The next figure shows another option, which is the combined cycle. This flow sheet shows the same equipment as on the previous two sheets of the combustion turbine driving a generator and exhausting into a heat recovery boiler, but in this case the steam is generated at a higher pressure and is piped to the throttle of a steam turbine generator which produces additional electric power while extracting low pressure steam for heating and cooling the campus. Again, a small portion of the steam would be used to cool the latter stages of the steam turbine and be condensed in the condenser. Utilizing the 100,000 lb/hr. of low pressure steam requirement and the same combustion turbine producing 20,000 KW of electric power, the fuel requirement for the turbine would increase to 300,000,000 Btu's per hour. Steam would be produced at 600 psig, 750°F. and when piped to the steam turbine, could produce another 5,000 KW of electric power while extracting 100,000 lbs/hr. of low pressure steam at 20 psig. The fuel, again, would be natural gas or No. 2 fuel oil.

You may look at that flow sheet for the combined cycle and say, "Oh, that's much too complicated an installation for a college campus, and who would want that". Well, obviously, the reason for putting it in is to save money on the production of electric power and heating and cooling so as to reduce your energy bill. Actually, this very system was installed with our firm providing the engineering, at Texas A&M University about 15 years ago, and it is still performing very satisfactorily today. The incentive then, and now is to provide the lowest cost source of electric power and heating and cooling for the campus.

If the amount of electric power generated exceeds the campus requirement, the surplus power can be sold to the electric utility company in the area. That company is required by the Public Utilities Regulatory Policies act of 1978 to purchase your surplus power at their full avoided cost.

The next figure shows the relative costs of the installed equipment for each of these three systems we've just discussed with the steam boiler/steam turbine generator cycle estimated at about $5,000,000. The combustion turbine with heat recovery boiler would be about $10,000,000, and the combined cycle would be about $12,500,000. The exact cost for each of these would vary with the local conditions and there are a number of factors which can increase or decrease these costs, such as the remoteness of the campus, the availability of adequate construction labor and so forth.

The next figure shows the annual savings to be realized with each of these systems. In determining these savings it is assumed that the 100,000 lbs. of steam could have been produced in a low pressure boiler utilizing as fuel any of the earlier mentioned fuels at an energy value of $5.00 per million Btu's. The savings then is the value of the electric power produced estimated at $.08 per KWH less the added costs for the additional fuel required.

It is also assumed that the generation of power and the requirement for the low pressure steam for heating and cooling is at 100% of capacity but for only 4,000 hrs. per year. This, of course, permits a simple calculation whereas the actual operation of the plant would be cyclic, both daily and seasonally, However, it should average something close to the figure we're using.

Thus, for the steam cycle, the net annual savings is $1,000,000 per year. For the combustion turbine cycle, which requires a larger investment, the annual savings is $3.8 million dollars per year, and the combined cycle, with the largest investment produces a net annual savings of $4.4 million dollars per year.

The next figure shows the time required for payout of the initial investment for each of these cycles, and this was arrived at by dividing the net annual savings into the initial cost with that cost adjusted for increased owning and operating costs. The result is that the steam cycle pays out in about 5.75 years, the combustion turbine in 3.0 years, and the combined cycle in 3.25 years.

It should be remembered, of course, that in addition to these savings, if you are utilizing energy produced from biomass such as the paper wastes on a campus, you would have an additional 300,000 dollars per year of reduced fuel cost.

All of the above is based on the assumptions as given, and of course, depending on your area of operation, those may not be the exact figures. Each individual case would require an engineering feasibility study to determine the exact costs and the annual savings to be realized.

In conclusion, it seems obvious that energy conversion from wastes is attractive in view of the high cost of energy today and also the use of co-generation can reduce your total energy bill significantly.

BOILER/STEAM TURBINE GENERATOR

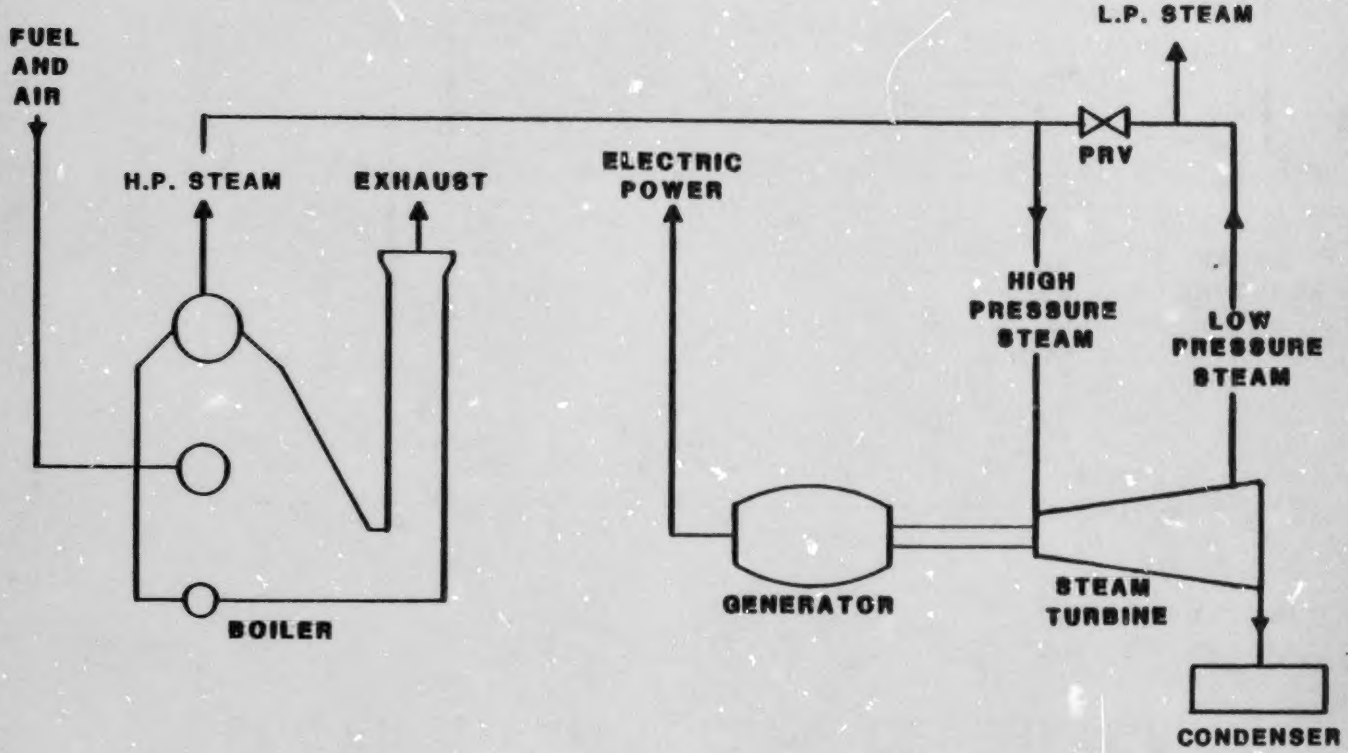

FUEL AND AIR
H.P. STEAM
EXHAUST
BOILER
ELECTRIC POWER
GENERATOR
L.P. STEAM
PRV
HIGH PRESSURE STEAM
LOW PRESSURE STEAM
STEAM TURBINE
CONDENSER

FIGURE 1

BOILER/STEAM TURBINE GENERATOR

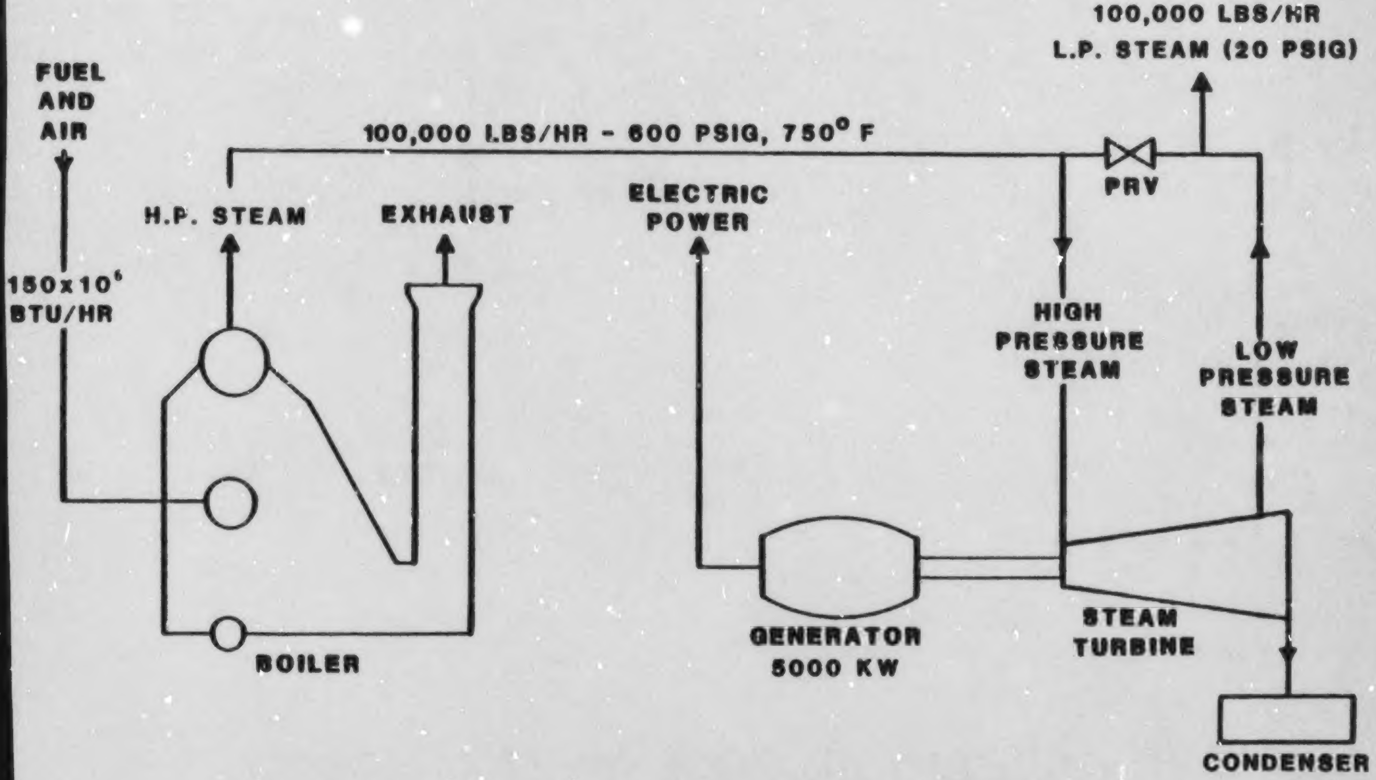

100,000 LBS/HR
L.P. STEAM (20 PSIG)
FUEL
AND
AIR
100,000 LBS/HR - 600 PSIG, 750° F
PRV
H.P. STEAM
EXHAUST
ELECTRIC
POWER
150×10^6
BTU/HR
HIGH
PRESSURE
STEAM
LOW
PRESSURE
STEAM
BOILER
GENERATOR
5000 KW
STEAM
TURBINE
CONDENSER

FIGURE 2

COMBUSTION TURBINE/HEAT RECOVERY BOILER

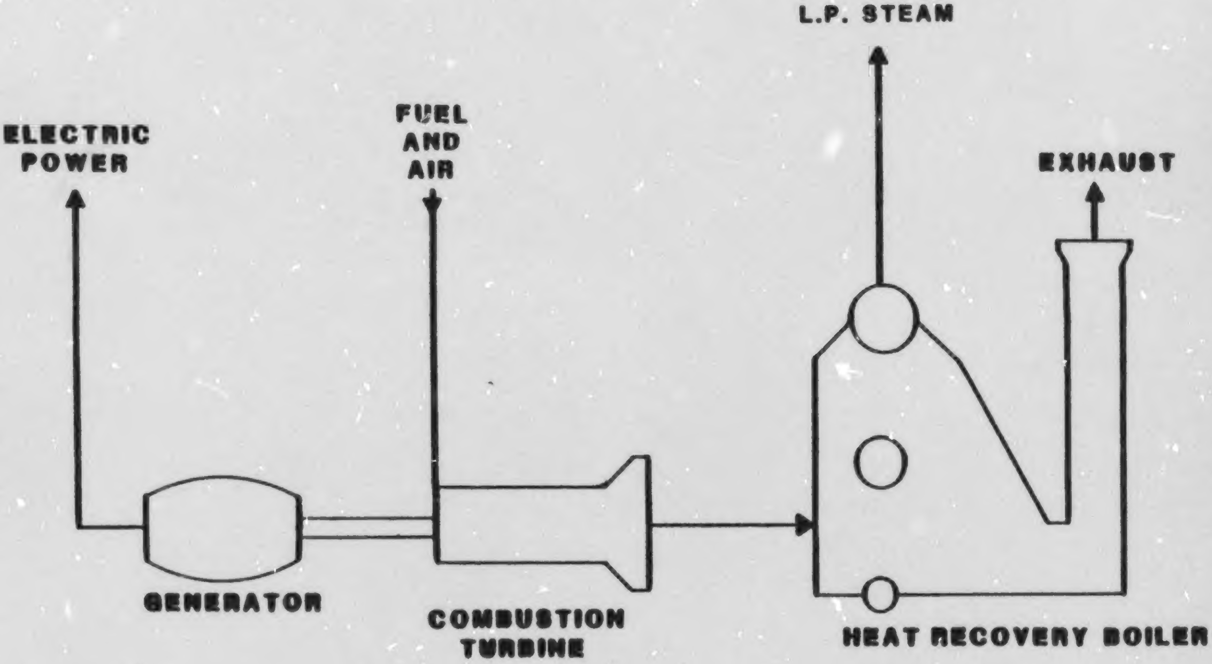

L.P. STEAM
ELECTRIC POWER
FUEL AND AIR
EXHAUST
GENERATOR
COMBUSTION TURBINE
HEAT RECOVERY BOILER

FIGURE 3

COMBUSTION TURBINE/HEAT RECOVERY BOILER

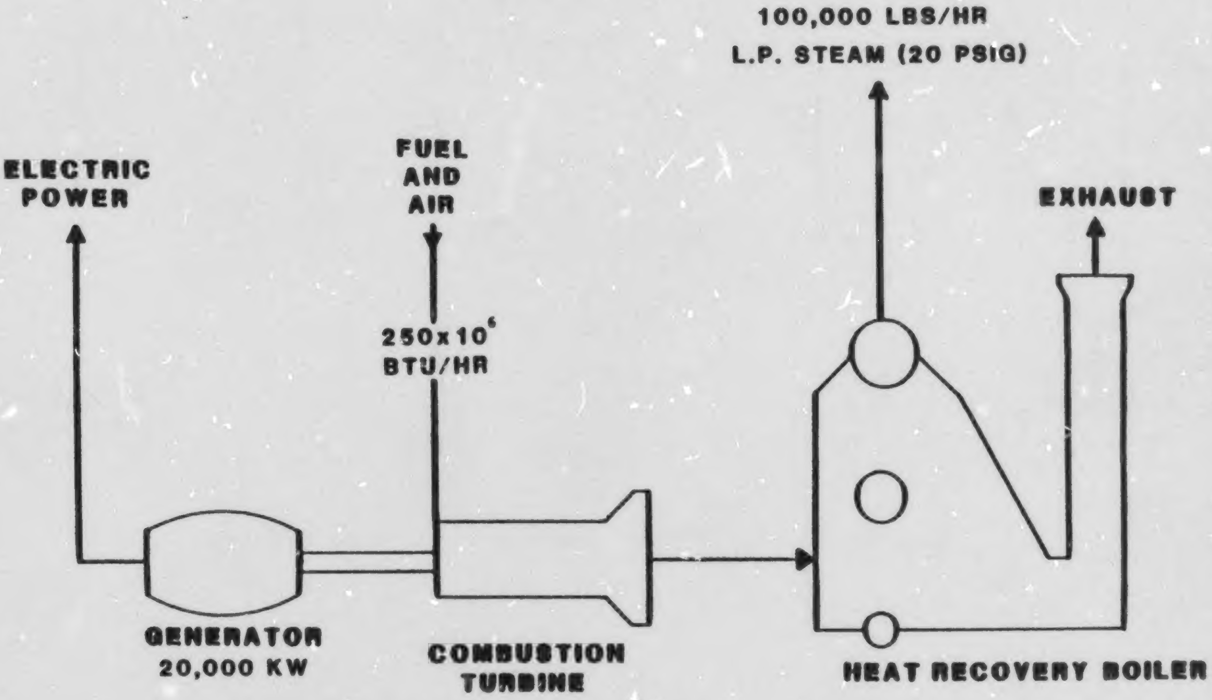

100,000 LBS/HR
L.P. STEAM (20 PSIG)
ELECTRIC POWER
FUEL AND AIR
EXHAUST
250x10^6 BTU/HR
GENERATOR
20,000 KW
COMBUSTION TURBINE
HEAT RECOVERY BOILER

FIGURE 4

COMBINED CYCLE

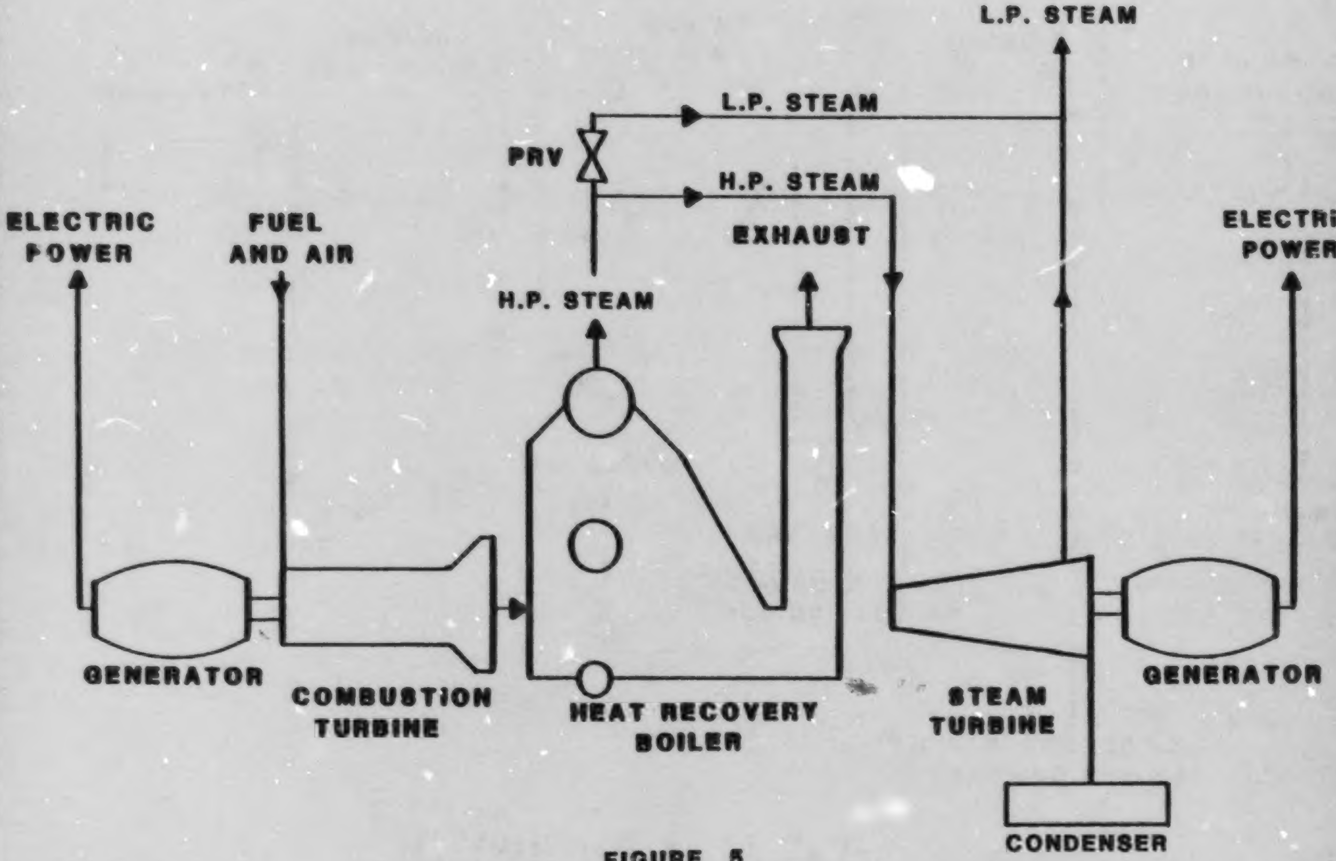

L.P. STEAM
L.P. STEAM
PRV
H.P. STEAM
ELECTRIC POWER
FUEL AND AIR
EXHAUST
ELECTRIC POWER
H.P. STEAM
GENERATOR
COMBUSTION TURBINE
HEAT RECOVERY BOILER
STEAM TURBINE
GENERATOR
CONDENSER

FIGURE 5

COMBINED CYCLE

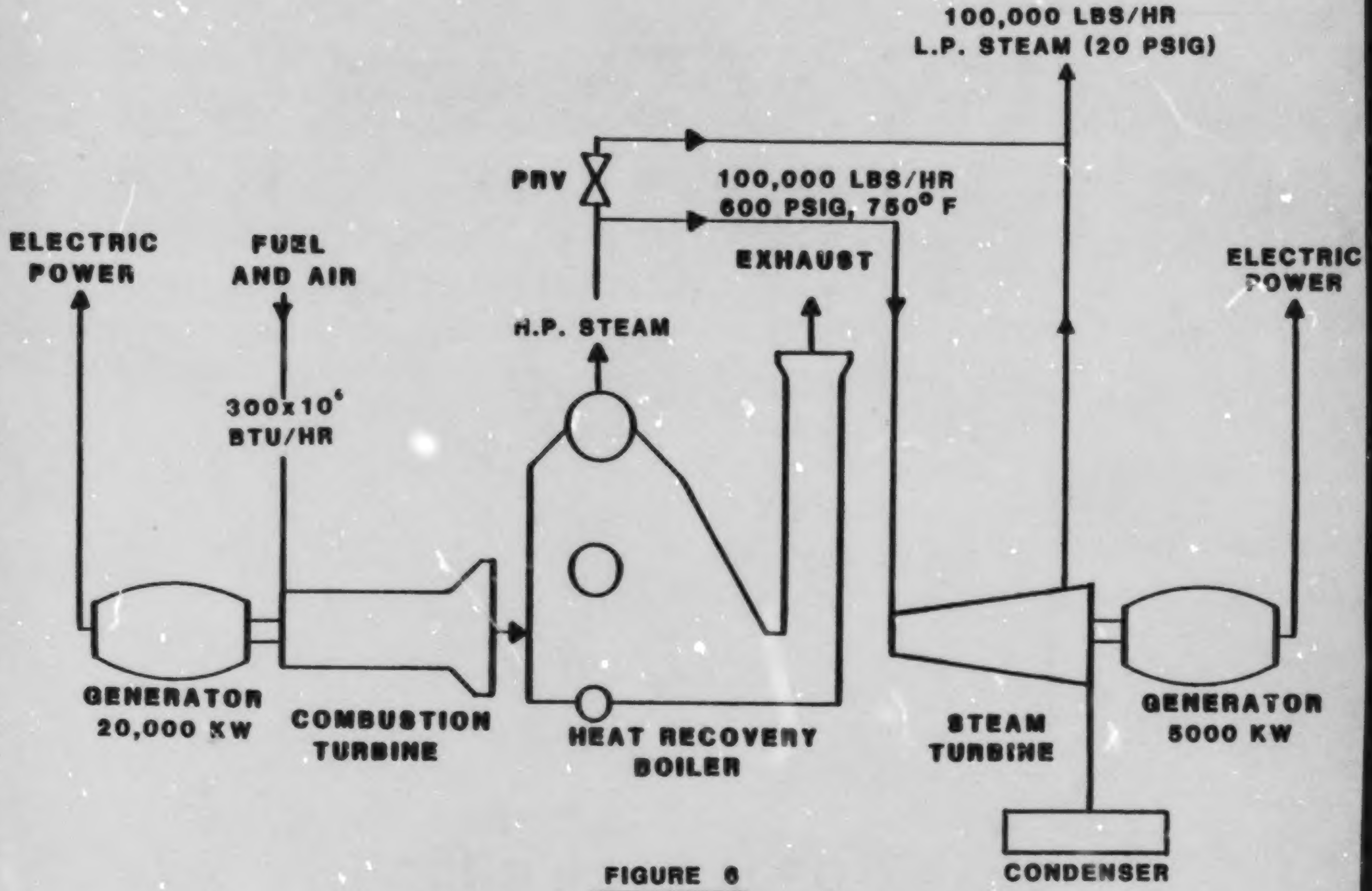

100,000 LBS/HR
L.P. STEAM (20 PSIG)
PRV
100,000 LBS/HR
600 PSIG, 750° F
ELECTRIC POWER
FUEL AND AIR
EXHAUST
ELECTRIC POWER
H.P. STEAM
300x10⁶ BTU/HR
GENERATOR 20,000 KW
COMBUSTION TURBINE
HEAT RECOVERY BOILER
STEAM TURBINE
GENERATOR 5000 KW
CONDENSER

FIGURE 6

COST ESTIMATE

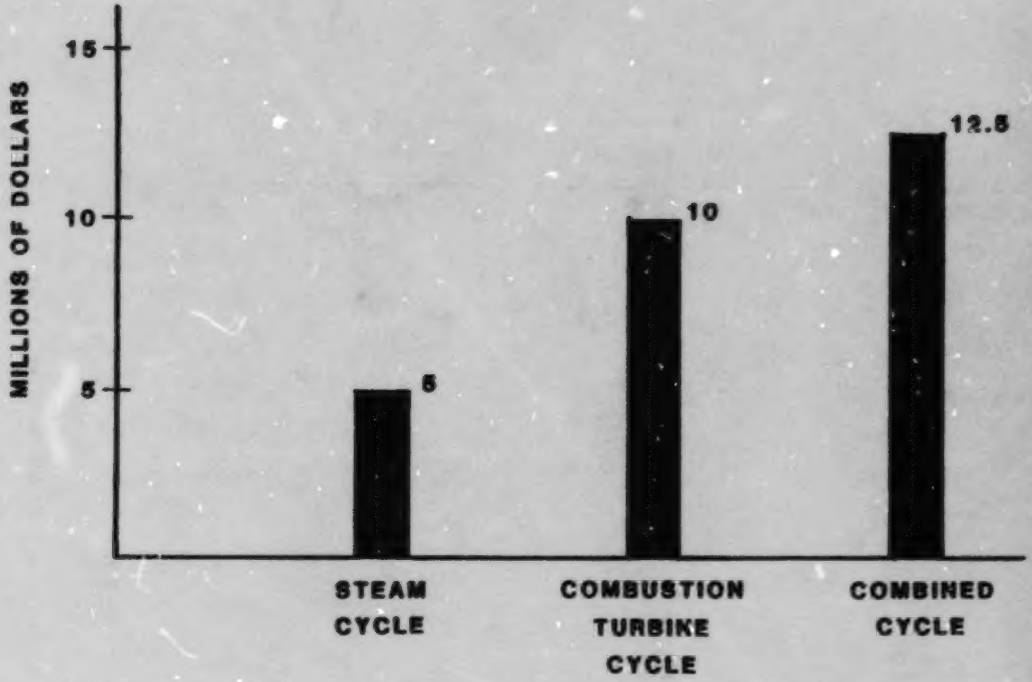


FIGURE 7

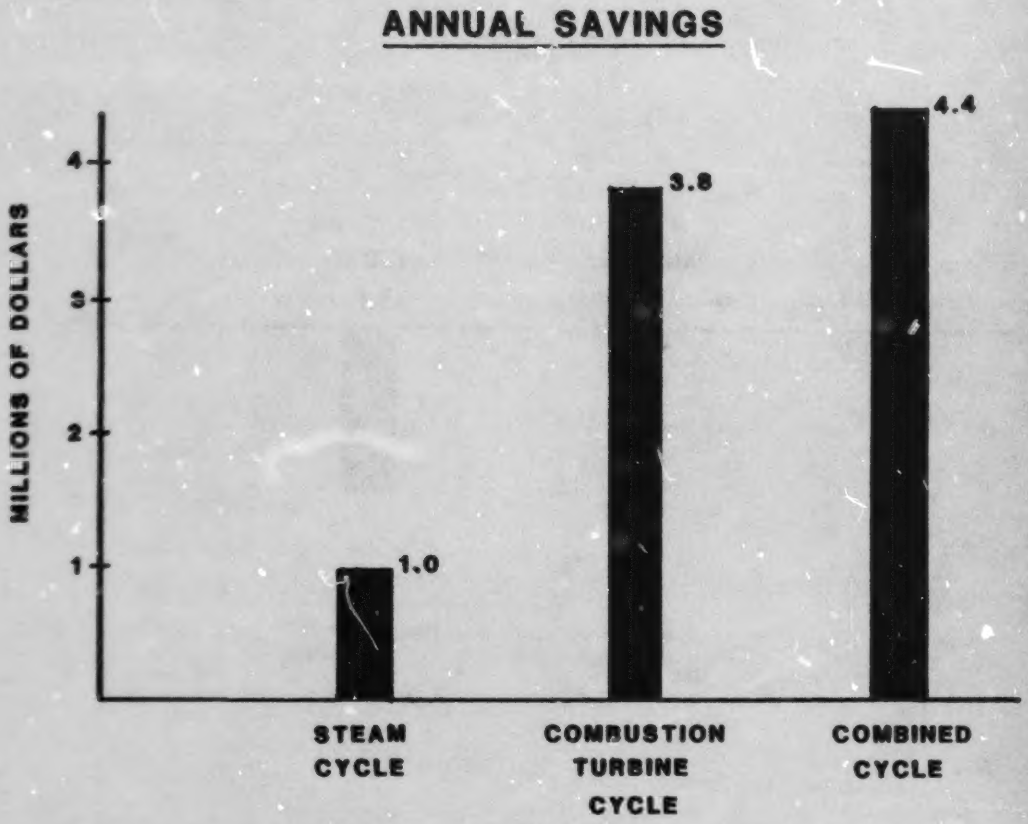

ANNUAL SAVINGS
MILLIONS OF DOLLARS
4
3
2
1
1.0
3.8
4.4
STEAM CYCLE
COMBUSTION TURBINE CYCLE
COMBINED CYCLE

FIGURE 8

PAYOUT OF INVESTMENT

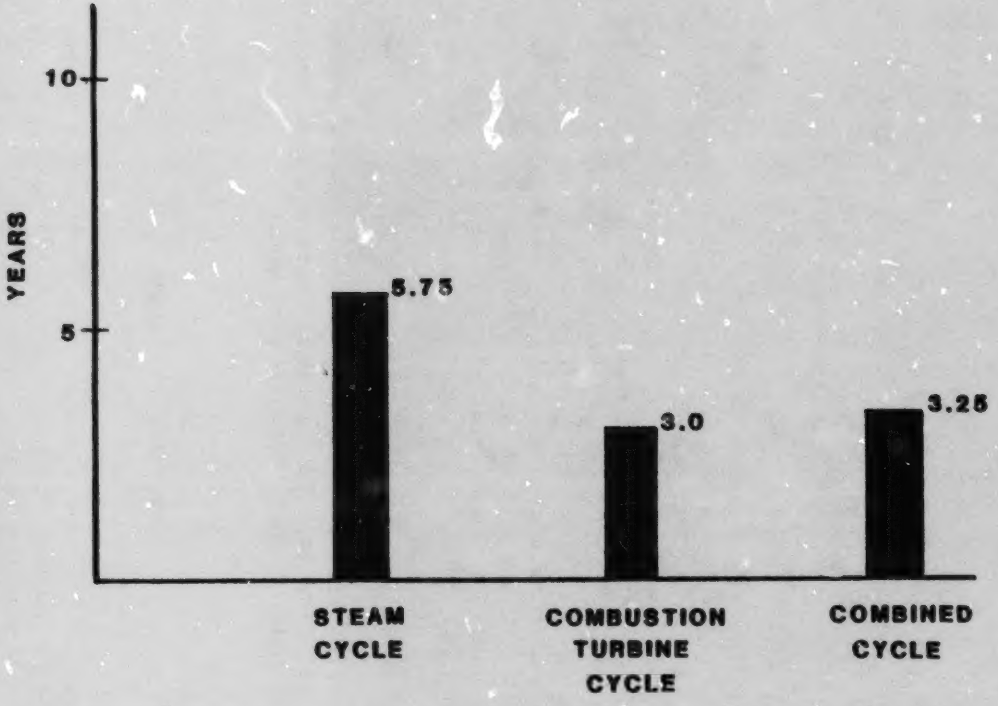


FIGURE 9

New Features of Campus Automation Systems

By Gregory A. Bruns
Honeywell Inc.

Introduction

This morning's topic is aimed at you. You know your physical plant, your operating environment, your special needs better than any of us in the building control industry. So what's our job? We're chartered to serve you, our customers. We do this by marketing what I'll call "relevant technology."

You can read just about any magazine and you'll find at least a couple of articles on advances in technology - specifically electronics. This is the electronic age - what does that mean to you? Well, short of casual interest or a hobby, technology advances have little to do with your professional function unless somebody makes them relevant to what you're trying to accomplish. That's what "relevant technology" is all about - making the latest technological advances applicable - or relevant - to your needs. In order to be relevant, the technology must be cost effective and capable of being maintained at a reasonable cost. This morning I'd like to address a few of what we believe are real needs and give you an example or two of how industry is relating technology to them.

Campus Needs

You're chartered with insuring that your physical plant - and consequently the campus runs efficiently. To that end, there are four areas that contribute to your goal which I would like to deal with:

Reliability
Flexibility
Optimized Performance
Working Information

Reliability. Let's spend a minute on reliability. Without getting too wrapped up in the methodology of measuring it and so on, the systems our industry provides have three areas of vulnerability - or areas where reliability becomes of prime importance - the Central Control Room, your remote panels and the transmission network that ties them together. A failure anywhere can knock-out control to a fan room, a building, half the west campus or worse. Fortunately, there are many techniques that can be used to improve reliability; we'll discuss a new transmission method.

Flexibility. How many times a year do your people have to take special action because of some unscheduled event? When you think about it, a sizeable percentage of thoses occurences probably had something to do with lighting. This, of course, is in addition to the scheduling changes every quarter or whatever.

Optimized performance. This is a major item on everybody's list today. Optimized performance obviously saves energy and money. But where's the best place to do the optimizing? It's a reliability and cost issue as well as a technology issue.

Working information. Lastly, we can look at the management tools you need for your staff to perform their work efficiently. This includes parameter measurement and recording all the way through establishing and implementing maintenance programs and energy usage audits.

Technology has brought new concepts and solutions for each of these needs. I'd now like to take a few moments to address each directly.

Let's start with reliability. Distributed processing techniques place the processing closer to the actual equipment being controlled. This reduces the processing load on the central. It also allows certain processing tasks such as energy management to be controlled by the remote processors. CP reliability currently is very good, and since a single remote panel contains a small percentage of the total connected points, a single failure has minimal effect on total system functioning. The remaining element in reliability, then, is the transmission network.

What are the characteristics of the ideal transmission media?

1. Data security/integrity.

2. Noise immunity.

3. Fault tolerance.

4. Overvoltage protection.

Data security or integrity means what your CP transmits to a remote panel gets there without error. It also means that your signal can't be compromised - this is a critical consideration when fire alarm or security data is being transmitted. Methodology to accomplish this takes the form of parity checks, echo transmission, line supervision and so on.

Noise immunity is the ability of the transmission network to resist errors caused by EMI (electromagnetic interference). Noise spikes walking in through power supplies or cross-coupled from adjacent power sources can severely affect data reception. Here traditional solutions have included extensive filtering, shielded cables and use of conduit.

Fault tolerance is the ability of the network to perform in an acceptable manner after something has gone wrong - usually a ground or a break on the cable. Here too, as fire and security functions are integrated into the system, the need becomes critical.

Lastly, we have overvoltage protection. This is the ability of the network to withstand an accidental short to 480 3-phase or, more commonly, an electrical storm. Many of the techniques used for noise immunity have been used here, with the addition of surge protection. Unfortunately, this is one area where the protection has not been adequate many times, and even if it has been, one good lightning strike will blow the surge protectors anyway, leaving you vulnerable when the next storm comes.

Now to offer an example of how technology can improve on this reliability consideration.

The transmission of data via light pulses is nothing new. Fiber optics - as applied to commercial systems - is. While the technology of fiber optic transmission has been around for a few years, only recently has the cost of components dropped to a level where the commercial marketplace can effectively use it.

The operating principles of a fiber optic network are really quite simple, as shown in figure 1.

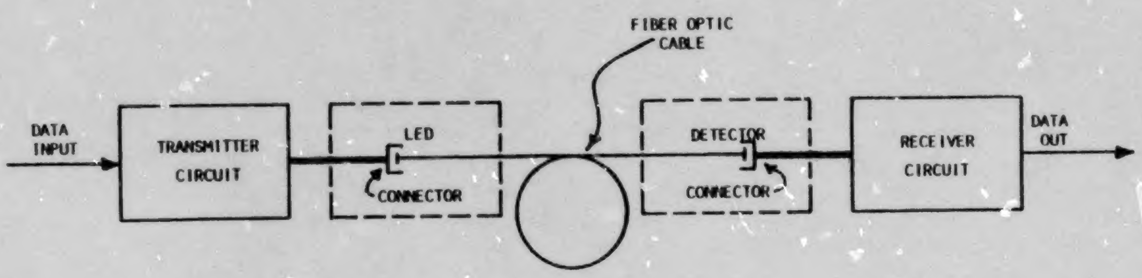


Figure 1.

- Serial data is converted into light energy via an emitter (a light emitting diode for simplicity).
- The light energy - in the form of pulsed data - is sent down a fiber cable.
- A photo-transistor (detector) at the receiving end converts the light energy back to a digital voltage type signal.

The networks can get pretty sophisticated, with different wavelengths (colors) acting as different "channels," allowing multiplexing of data. But even in simple form, the advantages are obvious.

Signal integrity is very high - the prospect of compromising the network is extremely remote. To defeat the protocol would require a complete duplication of the network, and substitution while the system continued to operate.

Noise immunity on a fiber transmission system is the highest currently available. Since the fiber is not a current or a voltage-carrying media, no EMI noise can be cross-coupled onto it.

Fault tolerance is another area where fiber is superior. No current or voltage signals means no effect due to grounds. There is no such thing as a short. The only fault can be a break - an opening in the cable. This can be averted by looping the cable back from the last panel to the central - now the system operates with a single fault - add a second fiber and you can tolerate two faults. The possibilities are many and varied.

Finally, there is the overvoltage question, and again fiber optics clearly shows its superiority. Immune to transient voltages, the fiber protects itself and connected devices completely. Even a direct hit on the cable can't damage a device down line.

What's the experience with this transmission media? It has been successfully installed by ourselves and others in several different building types. Here are Honeywell installations that are completed and operating:

1. The Honeywell Center - Atlanta - Installed

2. Cheshire Hospital - New Hampshire - Installed

3. Micro Switch - Galena, Illinois - Installed

4. A high security nuclear facility

Our experiences have been excellent - and this is over six years of installed history.

Flexibility. Now we'll talk about the flexibility of your operations and systems. All of you know that lighting is a major component of your total energy budget. Estimates often place lighting energy as high as thirty to forty percent of your total energy.

Instructors naturally want lighting available whenever and wherever they feel necessary. Special events such as seminars, guest speakers, concerts, forums and the like demand special lighting attention.

Schedules change - if not quarterly, then at some other interval.

The instructor may forget to turn lights off. So when his class breaks up at 9:30 - the lights are on 'til 11:00 when the next group uses lecture hall 1 West B. The opposite side of the coin is the nasty phone call or memo when some added late seminar couldn't meet because the maintenance crew or guards turned off the building lights, and the instructor didn't know what to do.

Naturally, you expect your BMS to accomodate schedule changes; and you anticipate, wherever possible, specific requests. What you can't plan for - and consequently sometimes can't accomodate - are thoses spur-of-the-moment demands.

Picture a lighting (or breaker) panel in one of your remote buildings. You may have put a timer in that equipment room to conserve energy. Your staff resets that timer to conform with class schedules once every term. How do you accomodate the special need? Usually by dispatching a maintenance worker to the site to make sure the lights get turned on and hopefully turned off.

There's a better way. Systems today can provide easily changeable time-of-day and day-of-week scheduling of lights. You may want to consider presence-sensing devices for certain rooms, eg. storerooms, restrooms, and mechanical rooms.

Override devices can include switches in the lighting area, photoelectric sensors or a touchtone telephone arrangement. This is a natural integration of telecommunications technology and building management systems technology and it is relevant to your needs.

To assure that lights are "off" after certain hours, the system can sweep through designated lighting zones on an hourly basis. Not only does this arrangement save headaches, it saves energy as well. Figure 2 shows the savings you can obtain per thousand square feet with a twenty percent lighting load reduction.

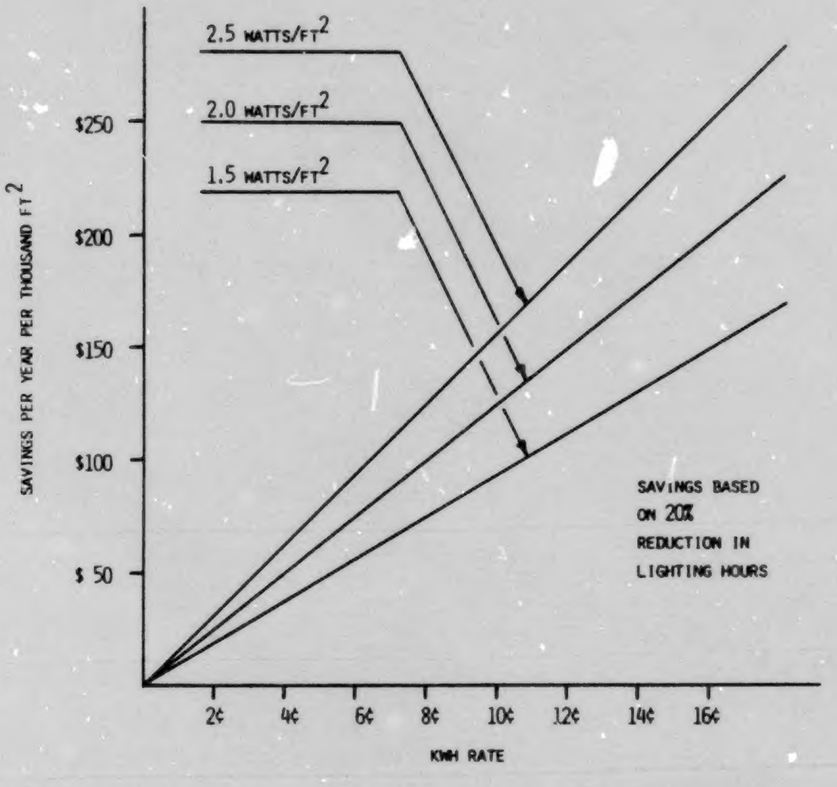


Figure 2.

Pick your lighting level curve, you KWH rate and read your savings down the vertical axis. Your late-1970 vintage buildings and newer run about two watts per square foot - your older buildings somewhat higher on the average.

Now let's talk about optimizing the performance of your systems.

By optimized performance we mean optimized energy consumption and consequently lower energy costs. How and where do you optimize performance?

Up until a few years ago the intelligence of a system was inherently CP based. In the late 1970's, microprocessors dropped in cost to the level where Honeywell and others began distributing processing functions, and consequently intelligence. Today satellite processors and intelligent data-gathering panels are becoming the norm.

Now, add to this the appeal of Direct Digital Control and you've got a package guaranteed to confound to most intelligent physical plant administrator. Why?

DDC is relevant technology. It's here - today - ready for your use - to optimize your operations - providing that it's applied to those functions it can do best.

Let's talk about what DDC is. From a purely engineering standpoint, DDC is the replacement of a pneumatic or electric analog control system with a digital "microprocessor based" system. In other words, we're taking temperature - an analog variable - and improving its control by treating it as a digital value repeatedly measured over a time period. Does that sound overly complicated?

Let's look at four differences between a traditional control system - pneumatic for example - and DDC. As I just mentioned, the traditional system continuously monitors the variable such as temperature. The DDC system measures the variable at discrete, short intervals - a technique called sampling. In the traditional system, the controlling output is a continuous signal relating to the sensed variable. The DDC system executes a programmed sequence each time the input is sensed - this sequence determines the output.

The second major difference is that the traditional system controller is a single purpose/single sequence device. If you want to modify the sequence or operation, you probably have to change the controller. With DDC, a change in sequence or operation is accomplished by modifiying the controller's software.

The third major difference is that the traditional system is stand alone and local. Controllers cannot share information and it's almost impossible to incorporate a centralized operators terminal. With microprocessor-based DDC, information can be sent from one controller to another via a data bus and an operator's terminal can be added to that bus making centralized control both practical and cost effective.

Finally, the DDC controller can have on-board intelligence required to implement energy management functions at the local system level including:

Duty Cycling
Optimum Start/Stop
Load Reset
Enthalpy Control

DDC systems have three algorithms: proportional, integral, and derivative. (Control charateristics are shown in figure three.)

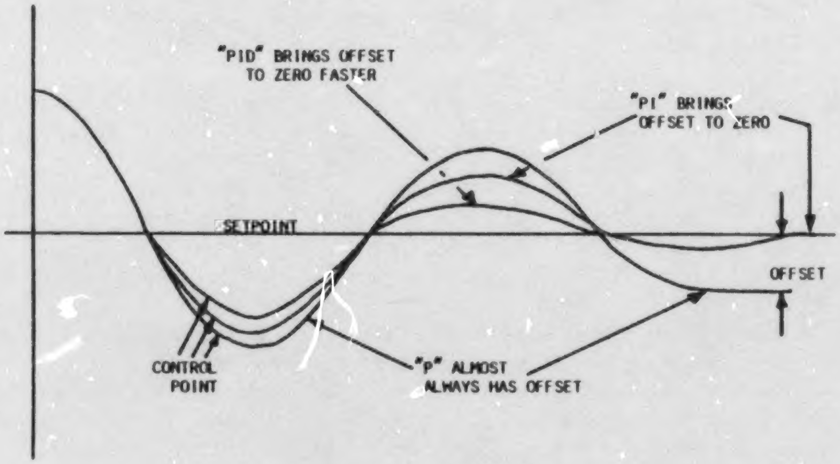


Figure 3.

Proportional is the control mode familiar to most of us. Think of the classroom heating application with a pneumatic thermostat controlling a radiator valve. The room temperature will be at the set point only when the heat supplied by the radiator valve at its mid position (half open) just balances the heat being lost by the room. When outside temperature drops and room heat loss increases, the valve will open further and offset between the set point and the room temperature occurs. Offset is characteristic of proportional control but in many situations, such as the radiator valve, it doesn't cause any great problem. In fact, it tends to conserve energy.

For another control example, consider a fan system with the mixed air control set at 55 degrees. The same general proportional control characteristics apply. Now as outside air temperature rises, the control will admit more outside air to try to maintain 55 degrees. Again the temperature will only be 55 degrees with the dampers at some mid position. As outdoor air temperature decreases, the mixed air temperature also decreases.

Another way to think of proportional control is how it reacts after a change. For example, when an air handling unit is turned on. The curve labeled "P" in figure three shows what happens.

With proportional control it goes through a settling-out process and maintains control at some value offset from the setpoint.

The next control mode to discuss is the addition of integral control to proportional control, or PI. The effect of integral control is to, over a period of time, eliminate the offset. It does this by periodically looking at the amount of offset and making a correction.

With PI control we note that there is no longer the offset. This feature in industrial controls is called "automatic reset."

Integral action is appropriate for discharge control systems because they respond fairly quickly and are often large systems. Straight proportional discharge control generally requires a wide throttling range to prevent hunting. A wide throttling range in this application, however, is often detrimental to the operation of the system. Adding integral action to proportional control will provide stable control with no discernable offset.

PI control offers some definite advantages for mixed air control which is, of course, a type of discharge control. With proportional control, the throttling range works against the system. For instance, as the outdoor temperature decreases, the mixed air temperature also decreases. For energy efficiency in systems suppling perimeter zones, the mixed air temperature should at least stay the same or even increase as the outdoor temperature decreases. Using PI control, the effective throttling range of the mixed air system is zero, making it more efficient.

In chiller control, small differences in chilled water temperature are important in terms of the cost of producing the chilled water and in the performance of the cooling coils using the chilled water. PI control can provide more predictable, more precise and therefore, more efficient control.

There are three things to remember about integral action, or PI control:

First, it operates only when there is a difference between the set-point and the control point. When they are the same, there is no integral action effect;

Second, its action is to keep the control point the same as the set-point no matter what the load is;

Third, it is best used on fast responding systems such as discharge control. On slow responding systems such as space temperature or dehumidification control, PI offers no real advantages.

It should also be maintained that PI control is obtainable with pneumatic type control. That is, it is not necessary to implement DDC to get the benefit of PI control.

A third control mode, derivative, can be added to PI control to make it PID control.

Derivative control provides an additional correction which depends on the rate at which the loading is changing. Here we still get the benefit of no offset and with derivative control we may achieve the control more quickly.

This derivative mode - sometimes called rate - provides the most correction when the rate of change is greatest. It is therefore very sensitive to the speed at which the process responds to changes of any kind.

One instance in which PID is appropriate is air flow control in variable air volume systems.

A word on PI and PID control. While they can offer great benefits when properly applied, they should never be used just because they are there. Due to their complexity, they take more time to install and start up than straight proportional control. The derivative function, in particular, requires extensive system tests to properly adjust it. It is important to keep in mind that the simplest control mode which will provide the desired results is the one to use. Attempting to apply very complex control modes can lead to poorer control.

Let's look now at another group of benefits that come with DDC.

The use of DDC means a greatly increased application flexibility for control systems. You now can easily handle complex control sequences or a number of different control sequences without hardware wiring or piping modifications. This is true because the changes are implemented through software. Some examples are:

1. A special start up sequence for partial occupancy during construction.

2. A special test sequence to exercise HVAC systems completely for building turnover.

3. A default sequence used in the event of system failure to provide minimal operation during trouble-shooting.

4. A standard sequence for operation under normal conditions.

Add to this the ability to modify your control modes to better suit your application and you have a powerful system.

So you can see how DDC can optimize your system's performance - if properly applied.

Lastly, I'd like to address operating information. This is one area where building management systems have not been fully utilized. When you think about it, the same technology that's being used to control and monitor systems on your campus can also be used to gather information on them and help your staff respond to that information.

Knowing the running time for an air handler is a nice feature - but having your system generate a maintenance work order for filter changing, belt inspection, etc. is clearly a desirable extension of system performance (as exemplified by the flow chart shown in figure 4). Add to that housekeeping functions of specifying materials needed, time by which the task should be done and a historical file for results and you've greatly improved the efficiency of your crew.

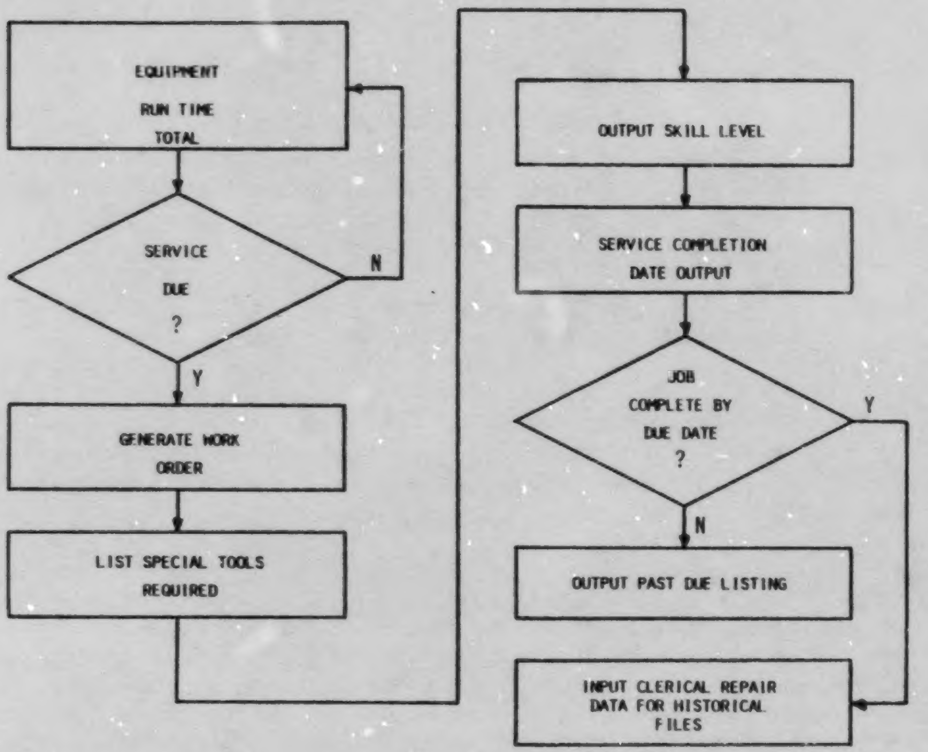

EQUIPMENT
RUN TIME
TOTAL
SERVICE
DUE
?
N
Y
GENERATE WORK
ORDER
LIST SPECIAL TOOLS
REQUIRED
OUTPUT SKILL LEVEL
SERVICE COMPLETION
DATE OUTPUT
JOB
COMPLETE BY
DUE DATE
?
Y
N
OUTPUT PAST DUE LISTING
INPUT CLERICAL REPAIR
DATA FOR HISTORICAL
FILES

Figure 4.

Analogous to this is the ability to monitor or audit energy consumption throughout the campus. This can be done by building, department, whatever. Here systems can provide a simple method for generating your own reports, in a format you choose. Historical performance versus last year or your own model can be compared, calculated, even charted.

The transmission network of your BMS is a valuable tool to gather information - not only issue commands.

In conclusion, let me restate the mission of the building controls industry:

> We're here to help you optimize your performance.
>
> We're chartered with making the latest technology relevant to your needs.

Continuous Inspection as a Key to Enhanced Maintenance Funding and Effectiveness

by R. Gene Shirley
University of Virginia

My topic will acquaint you with Physical Plant matters at the University of Virginia. Emphasis will be on the Continuous Inspection Program; however, I also want to present to you our general framework for maintenance management.

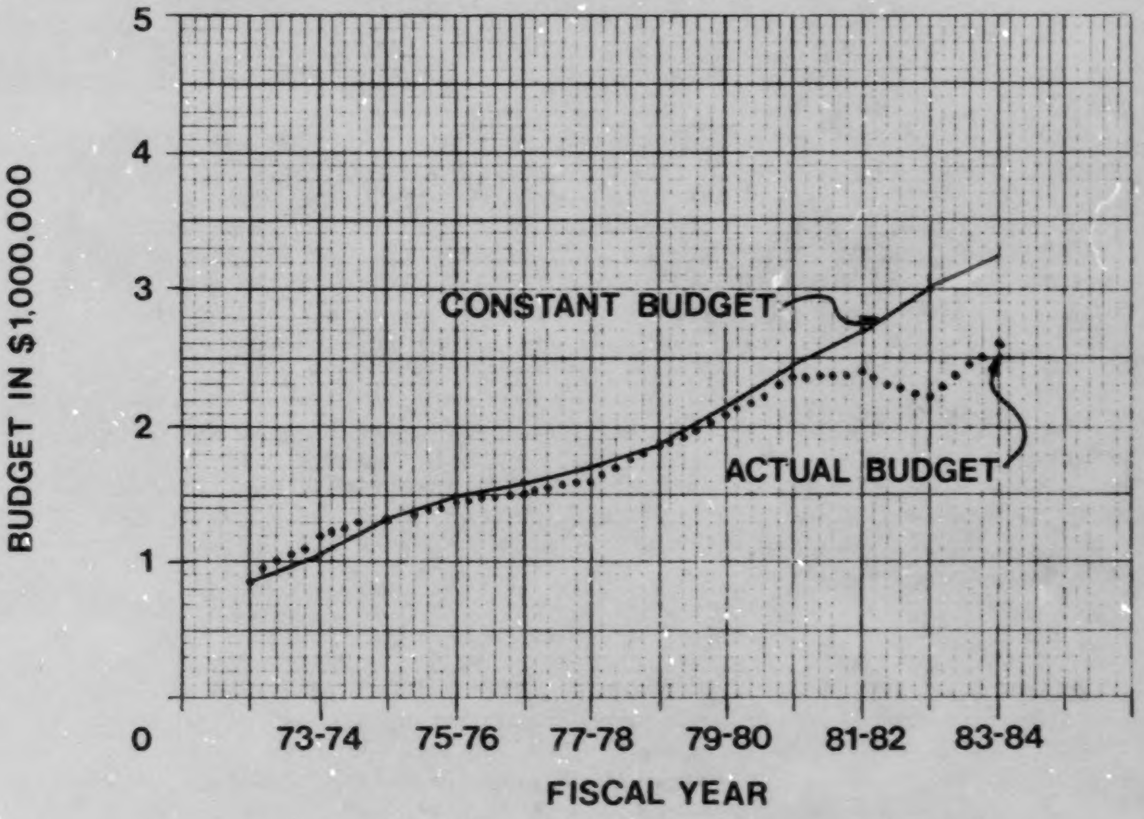
I have chosen my topic because of the financial climate at institutions today. Most institutions have found that the dollars available in operating budgets for maintenance have been shrinking because of economic conditions. Just when several years of intense study and attention led to almost universal acceptance of deferred maintenance as a problem of major proportions the economy became such that, in spite of the recognized need, funding availability at public institutions, in particular, was severely curtailed. Operating budget cuts were forced in many states; in some areas the budget dollars were actually cut, others just didn't keep pace with inflation.

Given the fact that budgets must be reduced, the issue generally comes down to pro rata reductions or maintaining faculty salaries and cutting services. Those in our business know that the decision, for the short term at least, is going to include cutting services. At the University of Virginia it has not been much different than elsewhere.

The University of Virginia follows a target budget approach. Each year Physical Plant is given a target dollar amount for budget development purposes. The target is inclusive of all our budgets for maintenance, utilities and services. It is determined by multiplying the prior year's budget by the determined percentages for inflation and salary increases. Obviously the target budget approach does not provide for new requirements or new facilities support. These are covered by addendum requests which turn out to be an exercise since they haven't been funded in the last two years.

In adjusting to the inadequate operating budget levels, we have given preference to cutting services and items which cause the least long-term impact: (1) janitorial services have been reduced 30 percent, (2) funding responsibilities have been transferred to auxiliaries, (3) interior painting cycles have been stretched to every 10 years, and (4) grass cutting and lawn care have been reduced.

OPERATING BUDGET FOR FACILITIES MAINTENANCE
UNIVERSITY OF VIRGINIA



The above graph demonstrates dramatically what has happened recently to our basic facilities maintenance budget despite all that we have done to protect it.

To develop this chart we reached back as far as we could get reasonably reliable data which turned out to be the 1972-73 fiscal year. A constant budget was developed by considering the effects of inflation, changes in missions and using the cost per square foot as the common denominator. As can be seen, the actual and constant budgets kept pace with each other until about two years ago. At that time the University was experiencing reduced funding availabilities, and the administration asked for Physical Plant to make cuts. Shortly after that the new Governor took office and made some arbitrary, across-the-board budget reductions in which we also participated.

One aspect of this chart which is worth noting is that, while it appears that for the decade 1972-82 the facilities maintenance budget was fairly well keeping pace with the mission increases and inflation, it was in 1981-82 that we had sufficient hard inspection data to place our backlog of deferred maintenance at $12 million dollars. In other words, maintenance and repair requirements were increasing at a rate greater than even the constant budget would have accomodated. Another $1 million dollars per year would have been needed to provide a maintenance level which avoided any growth in the backlog and also eliminated any preexisting deferred maintenance.

Physical Plant Organization

Let's look briefly at the organization we adopted in August, 1980. I'm not going to discuss the organization in great detail. It parallels closely the organization for public works activities in the Navy. This current organization used the old Department of Buildings and Grounds as the nucleus and added to it several fragmented components from other University areas, some of which reported through different Vice Presidents. The organization you see includes roughly 650 people, 95 more than Buildings and Grounds had. I consider it quite fortunate that we began putting in place our current organization and management staff in August, 1980, just ahead of the real financial crunch in our area.

The one area of the organization which I want to discuss in detail is the Work Management Division, since it coincides so closely with our philosophy and systems for the management of both facility maintenance and renovations. The principal functions performed within the division are: (1) work reception, (2) work order authorization, (3) project tracking, (4) planning and estimating, (5) maintenance service specifications, and (6) continuous inspection.

We have staffed our organization with eight Planner/Estimators. Most of these are former shop employees of ours who competed for the positions which were established at the Buildings and Grounds Supervisor "A" classification. In Virginia's pay system, this is three pay levels above a journeyman in the trades areas and one level above a foreman. Most of them are relatively young with a great deal of potential to grow in expertise and move into positions of greater responsibility. One former Planner/Estimator has already filled the position of Superintendent over the Utilities Distribution Division. The head of the Work Management area has 21 years experience in the facilities field and is a registered engineer. Work Management is the hub of the organization. Almost everything we do passes through or touches Work Management in some way. We have given the Planner/Estimators formal training by the Navy in the use of Engineered Performance Standards and the process of Continuous Inspection. Four of them have been to the APPA Institute, and we send each of them to a specialized course or seminar each year. Each man is a generalist for planning, estimating and inspection capability as well as a specialist in one or more facets of our operation. For instance, we have specialists in the areas of preventive maintenance, roofing, elevators, fire protection systems, painting, casework and janitorial work, as well as all normal trades.

I think of maintenance management as the sum total of all programs, procedures and controls which come into play when determining maintenance requirements and priorities for the optimum distribution of available resources. Maintenance management is accomplished through the organization as established, the placement of functional responsibilities and accountability.

Maintenance Management Model

Inventory
Maintenance Standards

Work Classification
Numerical Identification

Work Generation
Work Reception
Work Input Control
Planning and Estimating
Job Authorization

Material Coordination
Shop Scheduling

Reports
Appraisal

Every institution employs a maintenance management program of some sort. It will include most of the elements shown in the model above. Differing terminology may be used to describe these elements; however, for the most part the differences in the program from institution to institution will fall largely in how an element is handled and the emphasis placed upon one element relative to another.

Inventory and Maintenance Standards provide a foundation for a maintenance program. They determine what will be maintained and how well or to what degree. They provide a basis for evaluating the condition of facilities and the effectiveness of part or all of the maintenance effort.

Work Classification and Numerical Identification are necessary to identify work documents and to channel work accomplishment.

The next grouping of elements are functional controls applied in the processing of the work. How Work Reception, Work Generation and Work Input Control are handled will say a great deal about the stage of development of the maintenance management program. The degree of emphasis on Planning and Estimating and the use of such information is a good indicator of the sophistication of the program. Proper Job Authorization is extremely important if the workers are to be effectively employed on the work that managers want done.

Material Coordination and Shop Scheduling occur prior to and during the course of a job. They directly support the performance of work and directly impact upon the efficiency of job performance.

The last two elements--Reports and Appraisal--are tools to assist management in making judgments and decisions about the work which is being completed by the organization. If they are produced in timely fashion and used properly, they permit taking necessary corrective action during job progress and after completion, if needed.

Looking at the element which is called Work Generation will lead specifically to the place of Continuous Inspection in a Maintenance Management program. Work Generation identifies everything that could or should be done. It establishes the pool of tasks which compete for the available resources. Work Generation can occur in two ways:

Non-Inspection	Customer Work Requests Trouble Calls Emergencies
Inspection	Operator Inspections Preventive Maintenance Inspections Continuous Inspection

Continuous Inspection

A Continuous Inspection Program [illegible] a repeating cycle of scheduled control inspections of facilities to document physical conditions in areas such as mechanical, electrical, structural and roofing. These inspections can provide a number of benefits for any maintenance program including:

1. Examine items not covered by operator or preventive maintenance inspections.

2. Assure the adequacy of operator and preventive maintenance inspections.

3. Identify minor work for immediate corrective action.

4. Avoid building component failures.

5. Serve as a basis for maintenance and repairs to be accomplished in conjunction with renovations.

6. Identify and quantify the uncorrected backlog of essential maintenance and repairs.

7. Provide a firm basis for a constant flow of work.

8. Track corrections as they are made.

9. Support the continuing budget need.

The two leading drawbacks to a Continuing Inspection Program are: (1) time, and (2) data management. The field time to make inspections is only a portion of the total time requirement. For every hour in the field, the inspector will spend about five hours developing and expanding the inspection report. To facilitate field work, the inspectors carry a tape recorder and a building layout plan which is complete with room numbers and a directional arrow for north. At an institution of any size the inspection data will have to be automated in order to be managed and used to its fullest extent. The commitment of time and resources is essential for a successful facility inspection program.

We did make the commitment but have had to make adjustments in execution. At the outset we wanted to inspect important, mission-related facilities every year, and other facilities every two years. We have not been able to hold to the schedule and are just now completing the entire first cycle of inspections after two and one-half years. Future cycles are anticipated to require less time because of the inspection knowledge and expertise which we have accumulated. Nonetheless, we have revised our objectives to provide for essential facilities to be inspected on a frequency of two years and others at three-year frequencies.

In 1980, when we initiated Continuous Inspection, we attempted to do it on our own. We defined the program and the procedure and sent teams of newly-appointed Planner/Estimators to the field in their inspection capacity.

The early results were disappointing, as you might well imagine. The desire was there, but the expertise was lacking. We quickly wrote a Request for Proposals and advertised for a consultant to: (1) make facility inspections and completed reports for six major buildings, and (2) train our Planner/Estimators to be Inspectors. This worked extremely well. As most of you know, there are consultants available in every facility-related area, and we obtained an organization with experience and qualifications for our purpose in every respect.

Since the initial training, our people have carried on the program utilizing approximately 30 percent of their available time. We did fall behind at one point and contracted with a second consultant to inspect and provide reports on several more of our large buildings.

I previously covered the benefits which can be achieved through a program of Continuous Inspection. One of these was the identification and quantification of the uncorrected backlog of essential maintenance and repairs. Most call this deferred maintenance--the maintenance and repairs which just aren't being funded.

Capital Funded Deferred Maintenance

When it came time to submit the capital budget for the 1982-84 biennium, we had accumulated enough hard inspection data to project our unfunded backlog of maintenance and repairs at at least $12 million. Operating budgets for maintenance had fallen that much short of being able to provide a program which corrected all problems at the rate at which they were occurring. Citing specific requirements, Physical Plant introduced two deferred maintenance projects into the capital budget program. One project covered University-wide facilities, and one was for restoration work on our historic Jeffersonian structures. Recognizing our documented need, the University administration made these two projects priorities one and two in the capital budget submittal.

During budget hearings, key members of the General Assembly and the Governor came to Charlottesville to observe firsthand our major maintenance and repair problems. We let shop supervisors show them the extent of our needs. To make a long story short, when the legislation was passed we didn't get our two projects. We got something even better! The General Assembly provided an appropriation for Maintenance Reserve.

The appropriation was called Maintenance Reserve since it is intended to work like a bank account. The specific language of the appropriation reads that these funds are available to an institution to be used to the extent that annual operating budgets for maintenance are inadequate to cope with developing maintenance and repair requirements.

The Maintenance Reserve appropriation was allocated to Virginia educational institutions by a formula which was tied to the plant value. At University of Virginia our appropriation amounted to $4,209,890. While the funds do not expire at the end of the biennium, I anticipate no problem spending the entire amount by July 1, 1984.

As soon as the current Maintenance Reserve appropriation became available, we submitted projects from our Continuous Inspection identified backlog having a total value of $5,277,950 for approval of the Division of Engineering and Buildings. Several projects require consultant investigation and analysis in order to determine a properly-engineered solution. We want these studies to be completed now in order that actual corrective work can take place in future biennia. Meanwhile, less complex problems have been or are being corrected. The chart below shows the value of those projects for which we already have approval, about $1,000,000 over the amount which was funded. We have a total of nearly 100 projects arranged in priorities as shown here.

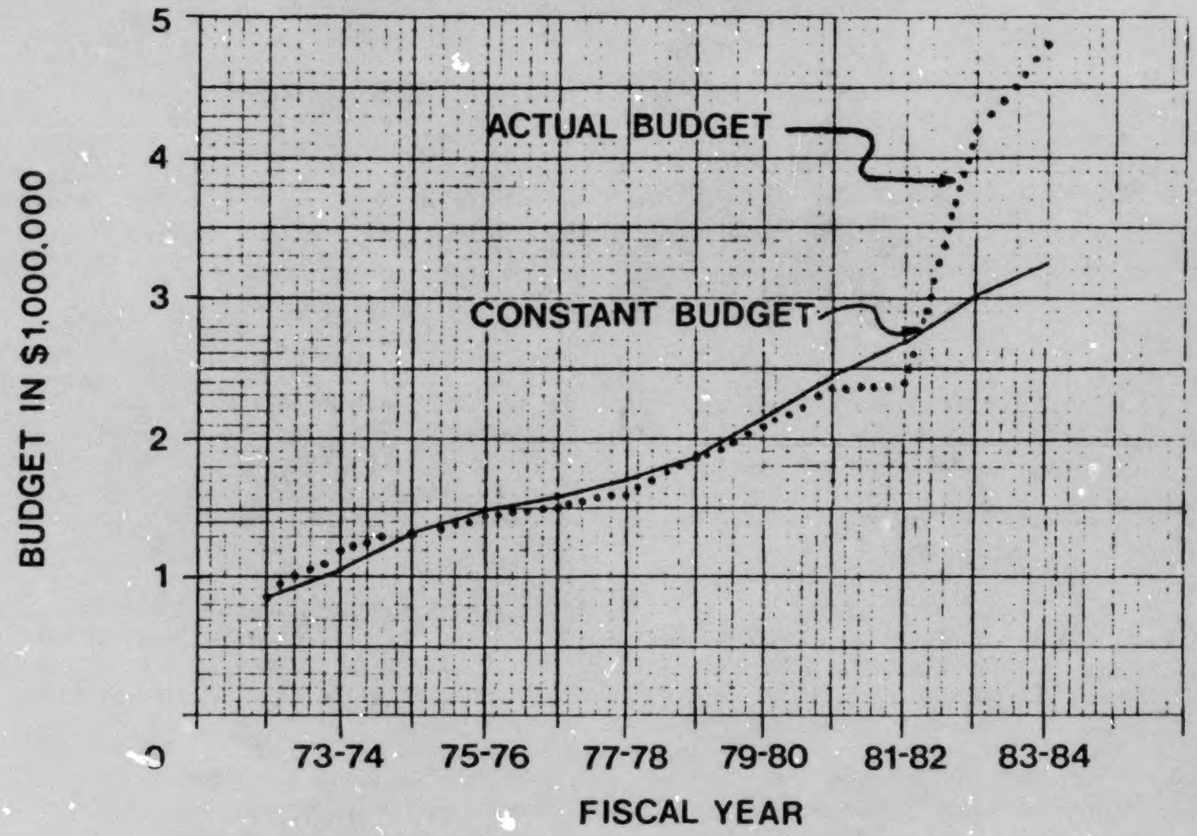
Summary of Planned Projects

Repair or Replacement of Roofs	$1,799,850
Repair of Jeffersonian Historic Buildings	980,000
Utilities Production and Distribution Repairs	1,015,100
Building Air Conditioning and Utilities Repairs	693,000
Other Buildings and Structures Repairs	790,000
Total - - - - - - - -	$5,277,950

Our approach is to treat Maintenance Reserve as a continuing appropriation from biennium to biennium. There is good evidence that the legislators were thinking of it as such. Accordingly, we have already prepared and submitted projects in the next three biennia.

My highlight is this chart. It is the same as Chart #1, except that the funding available through the capital budget has been added to the operating budget. For the immediate future, the two must work together. It is the combined total dollars which determine what we can do. If capital funding is not available, the justification is that much stronger for the operating budget. Given the capital budget, our economic condition is on the upswing.

BUDGET FOR FACILITIES MAINTENANCE
UNIVERSITY OF VIRGINIA



How to Pick a Maintenance Management System

C.K. Gold
C.K. Gold Associates

One of the most significant expenses to both Government and industry is facilities and equipment maintenance. On the average, over the lifetime of a building, operations and maintenance will be eight to ten times the cost of acquisition--and this ratio is climbing. Recent studies have shown that costs of labor intensive maintenance are growing at a higher rate than inflation, in fact doubling every four to five years.

The investment in facilities equipment may be thirty percent of the building acquisition costs and an even greater percent for firms with extensive production or research equipment. The overall investment in equipment can be the largest item of fixed costs. Clearly the efficient management of maintenance and operations merits close attention from decision makers.

There are two areas of concern: corrective maintenance (CM) and preventive maintenance (PM). Corrective maintenance is the **unscheduled**, unpredictable repair or emergency. Preventive maintenance is the **scheduled** inspection, adjustment, or minor repair to avoid an emergency or major breakdown.

Preventive maintenance (PM) is the most effective means of prolonging equipment usefulness and cutting down on repair cost. PM can reduce all the costs associated with equipment; that is, acquisition, repair, utilities, and production loss or downtime. Much depends, however, on the nature and amount of PM work performed. Too little preventive maintenance will not reduce repairs nor extend the life of the equipment. On the other hand, there is a point when added PM tasks no longer reduce the amount of repairs. A sound PM program must be developed, taking into account the realities of available personnel, hours, plant layout, and actual maintenance history on units of equipment as they exist in a given facility.

In short, the greatest promise for cost savings lies in the abilities of the manager to invest in PM, to prioritize repairs for the lowest overall cost of ownership, and to efficiently schedule and monitor the work of employees.

A complete Maintenance Management (MM) system will be able to handle four areas of management. These are Equipment Management; Building and Grounds Management; Inventory Management; and Project Management.

There are five steps or phases to establish and install a MM system.

The first step is to determine what type of computer will be used. There are three options: micro, mini, or main-frame computers.

The computer size is determined by the size of files (the amount of data) necessary to be processed and the numbers of terminals (locations to input or receive information) necessary for a specific operation.

The files consist of the Parts Inventory; Equipment Inventory; and Maintenance History. The size of the Maintenance History File is determined by the desired length of time over which the history is needed.

The type of additional computer hardware required, if any, is based on any equipment or system already in place.

The manager must determine what excess information processing capabilities are available within their current system. Secondly, determine the number and the location of terminals and printers that would be available.

At this point, a decision can be made as to whether the MM system can be implemented within the current system. If it cannot, then additional compatible hardware must be acquired or a new system set up dedicated to the MM function.

Once the computer selection is made and the system is operational, the next step is to establish a data base.

This is the basic information about your equipment and plant site. It is to include everything that needs ongoing maintenance or that would be inspected, repaired or replaced.

A precise count of each item is taken that are electrical, electromechanical, mechanical, hydraulic, pneumatic or if it moves. Inspection activities are defined for roof, walls, painting, grounds, etc.

The Data Base must contain the following information for each unit of equipment:

1. unit number
2. unit description
3. site
4. building
5. floor
6. room
7. manufacturer
8. model number
9. serial number
10. building system of which unit is a component
11. building subsystem of which unit is a component
12. purchase vendor
13. purchase order number
14. cost
15. lease or purchase
16. warranty end date
17. date installed
18. date entered system

The Data Base must also contain the maintenance data that applies to each unit. The data should accommodate up to seven service levels. For each service level, list:

1. frequency of performance
2. maintenance vendor if contracted
3. type of pricing arrangement for maintenance contracts and price
4. task synopses for up to four employee tasks per service level
5. for each employee task list:
    a. craft/trade
    b. standard hours
    c. tools/equipment required
    d. material/parts required

The next phase is to assign the protocol (what is to be done) and the frequency (how often) to each item. For example, grease A units' belts every six months; inspect B units' belts every month.

Protocol and frequency is based on the age of the unit, its environment and the job it's assigned, as well as any regulatory requirements.

Work balancing is the next step.

To eliminate workload peaks and valleys, PM tasks are spaced over the entire year. This is done for each trade and for each type of equipment.

Work balancing takes into account how often the equipment is used and when it is used (seasonal or every day, etc.). Also specified is when the best times to work on the equipment occur, as well as any geographical differences.

The work is spread over a 52-week period to achieve the most efficient maintenance operation.

The next step is to establish your Miscellaneous Files. The Miscellaneous Files provide specific information to complete work orders (tools, material and wage information); and gives specific files from which you can sort (location, priority status, system, etc.).

Examples are:

Tools and Materials
Site, Building, Floor, Room
Craft/Trades
Employee - Wages, Shift, Overtime
Manufacturer/Vendor
Backlog Status
Priority
Condition
Action
Cause

The last step is to load the computer.

Once the MM system is installed, it will be able to perform the following tasks:

1. produce work orders (corrective and PM)
2. record inventory and data
3. track maintenance history
4. record service calls
5. record backlog work
6. provide reports as basis for budgets, staffing analysis, program evaluation, performance evaluation
7. provide an audit trail of work through service calls, backlog, work orders and maintenance history
8. provide flexibility in work planning, scheduling, and assignment
9. provide an interactive and on-line add, change and delete capability for data bases
10. provide real-time access to all programs and data
11. provide simple English language and user prompts for all required functions
12. provide detailed instructions for data collection and loading by the user
13. provide detailed user or operator instruction
14. be operable by a clerk
15. handle up to 10,000 units of equipment
16. retain on-line up to five years of detailed maintenance history
17. retain on-line summary maintenance history for the life of the unit
18. be able to select, sort, and list equipment information for the life of the unit
19. be able to select, sort, and list equipment information by unit, location (site, building and room), equipment owner, class of equipment, type of equipment, manufacturer
20. be able to access, sort and list maintenance history data by work order, unit, employee, type of service (e.g., repair, PM)
21. be able to access, sort and list data on personnel by employee and craft/trade
22. provide status of outstanding work orders
23. facilitate scheduling and assignment of work
24. operate on a 16 bit micro-computer with 256K internal memory, a 10 MB hard disk with both CRT and printer capability

PM work orders must be produced automatically that contain: a unique W/O number, the unit number, unit description, location, type of service being performed, a task synopsis, a list of tools, materials and parts required. There must be places for inserting the employee's name, work time required, if the work was completed, and comments. A separate PM W/O card must be produced for each employee (up to four employees) and for each service level. The PM W/O must also provide for the separate reporting of any minor repairs performed during PM performance.

PM W/Os are produced with a minimum user input data such as week number and location. They are sorted by location, building, floor, room and type of equipment and craft/trade. A weekly summary is produced and sorted chronologically including the type of service performed. The listing has a space for inserting the employee as signed and completion date.

Each W/O can be displayed or reproduced individually at any time.

The MM system automatically produces a Service Call Log. The Log records the name and phone number of the person requesting service, the reason for the call, unit number, date and time of call and the caller's opinion of priority for service.

A repair W/O is automatically issued from the Service Call Log or it is placed in the Backlog or Deferred Maintenance Files.

Service Call Log data does not have to be reentered for producing a W/O or moving it to the Backlog or Deferred Maintenance File. Service Calls can be printed or examined on the CRT. This data can be updated or changed interactively and on line.

Maintenance work which cannot be performed immediately can be transferred to the Backlog data base. The Backlog provides the following data on each work project: the unit number; service call number; priority; project status (up to 9); time and cost estimate; date entered in Backlog; and a description of the work required.

Backlog projects can be printed or examined on the CRT by priority or craft. This data can be changed or deleted either on line or interactively.

Repair W/Os are produced directly from the Service Call Log, Backlog, or from Deferred Maintenance. Repair W/Os contain: W/O number; unit number; unit description; location; complaint or work to be done; number of employees and the craft/trade required. Space is provided for the name of the employee, time worked, whether or not the work was completed, date completed. Also there is space for the **condition** of the unit, what **action** was taken and the probable **cause** of the problem as well as any comments.

There is a separate W/O card for each employee. All W/Os can be printed out or displayed on the CRT.

A Work in Progress (W-I-P) File is automatically created for all W/Os issued. This file contains: the unit number, W/O number; Service Call Log number; Backlog File number; complaint or service to be performed; and the phone number and name of the requestor. Other information that can be entered into the W-I-P File as the work progress is: the assigned employee; date assigned; work status; whether completed or not; date completed; time required; material costs; equipment condition, the action taken and the probable cause of the problem; and any other comments.

The W/O remains in the W-I-P File until it is either completed, cancelled or moved to Backlog and another W/O is issued to complete the work. This file can be printed out or examined on the CRT either in its entirety or by work status. W-I-P data can be updated or changed on line and interactively.

Once the W/O has been closed, this data is automatically transferred to the Maintenance History File. The Maintenance History File contains the following information about every W/O issued: the W/O number; unit number; work or service performed; employee(s) assigned; time required; completion date; Service Call numbers; Backlog number; unit condition, action taken and probable cause; comments; parts worked on or replaced and the material costs. It is the historical result of all information returned on a closed W/O. This history is only as detailed as the completed W/Os.

Maintenance History can be printed or examined on the CRT. It can be retained and available on line for five years or more.

In general, the MM system has a numerical geographic addressing scheme for all equipment that tracks site, building, floor and room. All equipment can be tracked to building systems or subsystems.

Maintenance costs based on time worked and the employee's wage rate are computed automatically.

All PM tasks can be handled in frequencies up to five years. These intervals can easily be changed.

The system differentiates between in-house and contracted work. To save money, equipment under warranty or contract maintenance is automatically flagged.

Even if equipment does not require PM, W/Os can be issued, statused and repair history can be retained for all equipment.

In simple English, PM W/Os are issued on a weekly basis and repair W/Os are issued at any time.

Overall, the PM management system can give the manager the following reports as needed for effective cost, personnel, and maintenance planning and control:

The **Equipment Inventory** lists the complete equipment information by site, building and room.

The **Master Equipment Record** matches the Equipment Inventory with the PM service level. This also gives the year to date grand totals for PM and repair hours as well as costs.

Maintenance History lists all W/Os, PM and repair, separately and in total in sorted order for each unit of equipment. This gives a clear picture of what services were performed, by whom, how long it took, the cost, what the problems were and the current condition of the unit.

The **Annual PM Work Plan**, for a given site, automatically calculates and lists for each week (up to 52 weeks) the hours of standard PM scheduled for each craft or trade. This report also gives the weekly and annual totals for each craft or trade.

The **Mean Time Between Failures Report** tells how long each unit is in service, how long it was down due to service, the number of repairs required, and what was the mean time between failures. The Average Down Time report gives the same information but also lists the average time between failures and the date the unit was placed back in service.

The **Repair Cost as a Percentage of Purchase Cost Report** red-flags all units whose repair costs exceed "X" percent of the purchase price. This report gives the unit description, manufacturer, model number, total repair cost to date, the date that record keeping started, the date the unit was installed, the days the unit was in operational condition and the purchase price of the unit.

The **Employee Performance Report** enumerates for each employee the actual number of hours worked versus a standard of PM hours. Total repair hours are listed. And the ratio of actual hours of PM worked versus standard PM hours content for the entire trade or craft is given.

For each group of units which have identical PM tasks, the **Repair/PM Ratio Report** identifies the total repair and PM costs and gives the ratio.

Each week a **W-I-P Summary for PM W/Os** is issued that tells the number of W/Os issued and assigned, how many were completed showing both standard hours and actual hours. This report also shows the total of PM standard hours assigned but not completed and the total PM standard hours of W/Os not assigned.

Similarly, each week a **W-I-P Summary for Repair W/Os** is issued. This lists the number of W/Os issued, assigned and how many were completed. Those issued but not assigned, as well as those assigned but not completed, are also listed.

Finally, the **Repair/Failure Analysis Report** is given by unit and class of equipment for a specified time period. This analysis lists the number of repairs made for each type of repair. Some examples of repair type are: calibrate, adjust, replace. Listings are made by Action, Cause and Condition.

A **Work Management Program** will control all work orders pertaining to building and grounds. It will produce PM and CM W/Os and create a Maintenance History File. Report generating would be available as in the Equipment Management Program.

A **Project Management System** would allow the user to charge multiple work orders and inventory to a single cost center for cost tracking and planning.

And, lastly, an **Inventory Management System** that is interactive. It would charge to W/Os and maintenance history, keep up-to-date records of inventory items, and advise the user of order levels and the last three successful vendors.

In conclusion, a well-executed MM system allows management to bring more equipment and plant site under attention without hiring more staff.

Because of better planning, building and renovation programs are kept up to date. Thus, the most efficient work methods are utilized.

PM work on given equipment is performed at the correct time with the specified tasks.

Because the data is organized hierarchically and prioritized by the manager, all technical details of the entire building facility and plant are available at once. This enables the manager to get a clear and instantaneous picture of the conditions at all times.

Personnel are better utilized because of optimal scheduling. New personnel are more easily trained. Improved organization results in better morale. Success breeds success.

In the overview, the manager better knows what is being done, by whom, how much it costs, and has complete documentation to prove it!

Alternatives to Minimizing Employee Dissatisfaction

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The topic in the APPA call for papers to which I responded was "Minimizing Employee Dissatisfaction." But I don't want to minimize dissatisfaction. I want to maximize satisfaction. These are different topics! So my message today focusses on alternatives to minimizing employee dissatisfaction which will increase satisfaction. I plan to prove to you that an employee is only satisfied if motivated.

In view of our economic experience over the last ten years we have need for highly motivated employees. William James discovered in his research that motivation accounts for 50 to 70 percent of performance, with 20 to 30 percent being basic, and 10 to 20 percent representing peak potential. I know that out of 1000 employees in my own organization, I have an uncomfortably large number working at 30 percent of their capacity. I need to motivate them.

Considerable time and difficulty are involved in changing a group's behavior. Research by Hersey and Blanchard shows the sequence of events leading to improved group performance. First must come an improvement in knowledge, which leads to attitude change. Individual behavior alters after attitude changes; group behavior changes as a result of many individual changes. Managers need to do only those things which will eventually lead to improved group performance by motivated, satisfied employees.

Ten Happy Employees

To begin I want to introduce you to ten happy employees. Each of you attending this presentation knows employees in the organization you manage who fit the following descriptions. Five of these employees are satisfied. The other five are not now dissatisfied.

* This upholsterer recently received a promotion because he had been assigned more employees to work in his shop, which was so productive management decided to enhance the function.

* This employee just received a transfer he had requested for two months because he did not get along with his fellow workers.

* This stationary engineer works building HVAC in a 1.7 million square foot megastructure. He has just discovered that by rewinding a motor, changing a starter, and reshaping the fan blades, he could make the original fresh air system work without vibrating the structure. For six years the fans, subject of a major law suit, were not operated because they threatened to shake the building apart.

* This grounds supervisor worked virtually non-stop for sixty hours after the February blizzard to make sure the campus was ready to open Monday morning. His campus was the only institution within 100 miles open for business that day.

* This custodian submitted a line drawing to change the position of electrical outlets on the corridor she works. Her request was immediately completed.

* This police officer identified and arrested a wanted felon on campus. He recognized the suspect from an artist's composite circulated during his pre-shift briefing.

* This employee just got his first paycheck since the new collectively bargained contract went into effect. His take-home pay increased by 9 percent.

* This employee just learned that her children's orthodonture expenses would now be covered by an improved benefit package.

* This employee was assigned a new parking place which is much closer to her work location.

* This employee works in an office which was recently carpeted. The new finishes provide a more pleasant environment.

Although all ten of these employees are happy, the source of happiness for those in the first column is fundamentally different from those in the second column. The employees in the first column are satisfied with their work. The employees in the second column are not now dissatisfied with conditions of their employment. Whereas the source of happiness for employees in column one is found in the work itself, the source of happiness for employees in the second column is found in the work environment, not in the work itself.

Motivation and Behavior

We and our employees are all bundles of NEEDS. We direct our BEHAVIOR toward achieving GOALS we believe will satisfy our MOTIVES. Let's examine these ideas so we can understand why satisfaction is not the opposite of dissatisfaction:

Behavior is goal oriented, not undirected. Behavior is activity, not attitude, which is a different issue. Changes in behavior follow changes in attitude when change is not forced. And changes in attitude follow increased knowledge.

Goals are hoped for rewards.

Motives are needs, wants, drives, or impulses within an individual. Motives are often subconscious. Many motives can simultaneously influence behavior; the need with the greatest strength has greatest influence.

Needs Abraham Maslow classified human needs in a useful way. Many of you will be familiar with these descriptions:

- Physiological needs, usually associated with money, include shelter, food, and clothing. For most of our employees physiological needs are met.

- Security needs, or freedom from hazard, include benefits and personnel practices. For most of our workers benefits are excellent and personnel practices are prescribed by law or guarded by collectively bargained agreements.

- Social needs revolve around affiliation, the interpersonal relationships developed on the job.

- Esteem needs include prestige and power. Prestige is recognition, the deference shown by others in one's presence. Power, positional and personal, is the ability to induce or influence behavior.

- Self-actualization is the need to maximize one's potential. Two related motives are competence and achievement. Competence implies control over physical and social environment factors, job mastery, and professional growth. Achievement is the need to meet difficult but attainable goals.

Let's quickly assess the needs being met by our ten employees' behavior:

- Promoted upholsterer:
    Professional growth =
    Competence =
    Self-actualization

- Stationary engineer who fixed the fan:
    Job mastery =
    Competence =
    Self-actualization

- Grounds supervisor who conquered the elements:
    Control over environment =
    Competence =
    Self-actualization

- Transferred because of personality conflict:
    Social

- Pay raise:
    Physiological

- Improved benefits:
    Security

* Custodian who got electrical system changed:
Influenced behavior =
Power =
Esteem

* Police officer who identified and arrested felon:
Achievement =
Self-actualization

* Closer parking space:
Benefit =
Security

* Carpeted office:
Status =
Esteem

The five employees in the first column have met their needs for higher order esteem or self-actualization. The five employees in the second column have met physiological, security, social, or lower order esteem needs. Frederick Herzberg, researching what motivates workers, discovered an interesting pattern when he examined employee responses to questions about what did or did not satisfy them about their work. He found that when employees were satisfied, their needs for higher order esteem (prestige and power) or self-actualization were met. Herzberg termed these needs satisfiers. When people were dissatisfied, their physiological, security, social, and some esteem (status) needs were not met. Herzberg called these needs hygiene, or environmental factors. He found that when environmental needs were met workers were neither satisfied nor dissatisfied. Only the satisfiers have the power to make us cry or sing.

By the way, this observation helps explain why the consumers of physical plant services seem to complain every time something goes wrong, but not even notice when things are working well. Our services are environmental in nature, having little to do with the work of faculty, staff, and students! Tough medicine to swallow for those of us who agree with Walter Gropius that stimulative environment is an important element in the educational process.

Practices and Alternatives

Herzberg concluded that the following well-intentioned personnel practices fail to motivate or satisfy employees:

Reducing time at work. Motivated people want to work more, not less. Therefore, programs which reduce the workweek or provide flexible hours do not satisfy.

Increasing wages. Raises only motivate people to anticipate the next increase.

Improving benefits. Improved benefits contribute more to a welfare mentality than a work ethic.

Training in human relations. These programs teach managers to be more considerate, which is vital, but not how to motivate people.

Communicating well. Newsletters, opinion surveys, and face-to-face meetings help develop better knowledge and understanding, which are important to motivation, but they do not satisfy employees by themselves.

Counseling employees. Counseling programs help employees solve problems inhibiting performance, but don't motivate superior performance.

I certainly don't mean to imply that any of these programs aren't needed, because I believe they are. I want employees to be paid good wages, enjoy protection from benefit packages, have good relations with fellow workers, and gain status from their positions. But more than this, I want people to feel they are maximizing their potential at work. Important as good personnel practices are, they don't satisfy workers. Good personnel practices just keep employees from being dissatisfied.

John Morse and Jay Lorsch state that human beings bring varying patterns of needs and motives into the work organization, but one central need is to achieve a sense of competence. The need for competence continues to motivate even when a competence goal is achieved. Once one goal is achieved, a higher goal is set. As we have learned from Maslow and Herzberg, competence self-actualizes and satisfies employees.

So now we come squarely to the alternatives to minimizing dissatisfaction, which are those things managers can do to help employees achieve their competence goals through their work assignments. (Morse and Lorsch give us a warning that the competence motive can be fulfilled in different ways depending on how this need interacts with other needs, such as those for power, independence, structure, achievement, and affiliation. We want employees to be competent in their work, not in activities which are not consistent with the goals of the organization.) Herzberg terms managers' efforts to make employees' jobs satisfying job enrichment.

* Make assignments specific enough so employees can become experts at their tasks. The stationary engineer who fixed the air supply fans demonstrated expertise. Be wary of advice that you can save money and improve productivity by hiring handymen rather than tradesmen.

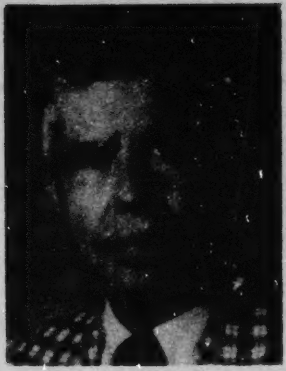
* Assign new, more difficult tasks not previously handled by an employee, thereby offering an opportunity for professional growth and achievement. To give employees the greatest chance for success in a new assignment, train them well. One example I can offer from Stony Brook is that we no longer contract for new minor construction, but have formed our own construction crew as I'm sure many of you have done. The eleven person crew went through $350,000 worth of materials in 1982, doing jobs as big as a 3000 square foot research laboratory. I believe those workers are motivated. Other opportunities might be found in high voltage electrical work, water treatment, environmental controls, or other places where you're paying premium wages plus overhead and profit for a contractor.

* Grant additional authority to deserving employees. To do so you might have to delegate some of your own authority. This approach has been well discussed.

* Remove controls while retaining accountability, giving progressively less supervision to workers who demonstrate an ability to produce with less direct supervision. This technique makes use of situational leadership theory.

* Increase each person's accountability for his or her own work by reducing crew size to the smallest effective number and assigning the smallest possible geographic zone to each crew. This is a way to induce pride of ownership among employees, giving them a complete, natural scope of work and an opportunity to be recognized by their customers for personal achievement.

I offer you these five alternatives to minimizing employee dissatisfaction, enough options to consume the rest of your administrative careers. Approach these alternatives from a firm belief that you can change employees' jobs to increase their satisfaction. Choose those jobs where productivity and attitudes are poor, where changing the job will not require large capital investments, and where improved motivation will have a measurable impact on performance. Finally, screen your plans to make sure you don't do anything just to minimize dissatisfaction. Thank you.



Evaporative Water Chilling

By Case A. Bonebrake
University of Arizona

The University of Arizona is located in Southern Arizona at Tucson, at an elevation of 2400 feet. The enrollment is about 31,200 including undergraduate, professional and graduate students. About 13,500 employees are on the payroll, and the expenditures for utilities were $7.25 million last year. All electric power is purchased currently at 5 cents per kilowatt hour, and the boilers are fueled with natural gas at the current rate of 60 cents per therm. There are two separate physical plants, each with its central heating and refrigeration plant. The main campus has about 5 million square feet and the medical campus has 950,000 square feet. The two are separated geographically by several blocks and a major six-lane traffic artery. The administration of the physical plants is under a single director, with maintenance and operating staff for each campus. Those of you who attended the APPA meeting at Tucson in 1971 will recall that the brand new medical campus was not yet in operation.

The local tourist bureau and Chamber of Commerce tout the mild winters, large amount of sunshine, and low humidity in wooing visitors from the frigid North. This mild climate results in relatively low heating requirements, with correspondingly high cooling loads.

On the main campus, over 5 million square feet of gross building area is served with steam and chilled water from the Central Heating and Refrigeration Plant. Building design, until six or eight years ago, has utilized low energy costs in the heating, ventilating, and air conditioning systems. Current designs which utilize economizer cycles, heat recovery, and multiple-stage evaporative cooling were not economically feasible when energy was cheap.

The result of this previous design is that many of the building spaces on the campus require cooling all winter, in order to dissipate the internal heat load. In colder climates, much of that load is dissipated through the building envelope. Research methods and equipment, particularly computers, in the modern University building demand a relatively stable set of temperature conditions, and many require humidity control as well. This necessitates round-the-clock operation of air handlers, which in turn requires round-the-clock chilled water supply. At the University of Arizona, this chilled water base load approaches 2,500 tons, with a peak summer load of 9,000 tons.

In December of 1979, an energy study by a consulting engineering firm was underway when the federal grant program for energy conservation for schools and hospitals was announced. The audit and analysis data was utilized for a successful grant application, and a project to install equipment termed a "hydronic economizer" in the Main Campus Central Plant was underway. The project consists of a bank of plate-and-frame heat exchangers and associated piping, which produces chilled water directly without operating the large centrifugal compressor.

During the winter months, the temperature of the chilled water supplied from the Central Plant can be increased from the typical summer temperature, 47 degrees Fahrenheit, to as high as 55 degrees Fahrenheit and still satisfy the cooling load. In the winter, the outdoor wet-bulb temperature is below 42 degrees Fahrenheit much of the time, normally 824 hours per year. This low wet-bulb temperature is significant in that standard cooling towers produce water temperature within 10 degrees Fahrenheit of the wet-bulb temperature at normal conditions. It was thus anticipated that 52 degrees Fahrenheit tower water would be available when the wet-bulb temperature was below 42 degrees Fahrenheit.

With plate-and-frame heat exchangers, 52 degrees Fahrenheit cooling tower water was expected to cool the chilled water to 55 degrees Fahrenheit utilizing the high effectiveness and heat transfer rates, due to thin film turbulence, large surface area, and low fouling characteristics. The heat exchangers consist of a series of gasketed, embossed metal plates clamped together between end frames to form channels between alternate plates, so that the warmer water flows on one side of the plate and the cooler water flows counter-currently on the other side, with heat transferred through the thin plate.

A group of four heat exchangers with a combined capacity of 2,500 tons was selected, since this capacity matched both the winter load and the capacity of each of two existing cooling towers. By parallel operation of the four heat exchangers, the pressure drop is near that of the condensers served by each of the cooling towers, so no pump changes were required. The bank of four heat exchangers is piped in parallel with No. 7 and No. 8 chillers, and can utilize the cooling tower and pump originally dedicated to its own chiller.

The feasibility of a hydronic economizer, along with energy and cost saving projections, can be determined using the following criteria:

a. Summarize daily weather data for several years to determine the number of hours per year when the wet bulb temperature is below the critical temperature, and derive an hourly profile for an average day of each month.

b. Establish the ton-hours usage during these hours from the Central Plant records.

c. Determine the hourly cooling load profile for an average day of each month.

d. By comparing the load profiles with the wet bulb temperature profiles, the annual ton-hours of cooling which can be provided by the hydronic economizer can be determined.

e. Using the annual ton-hours thus determined, the performance factor in KWH per ton-hour of the chillers, and the cost per KWH, the annual savings can be estimated. This saving can be compared to the estimated cost of installation to determine payback and feasibility.

The cost of the University of Arizona installation is listed here:

Purchase of 4 Heat Exchangers	$ 131,211.00
Design	17,000.00
Contract for Installation and Piping	112,068.00
Miscellaneous In-House Costs	12,181.00
Total Cost	$ 272,460.00
Less Federal Grant, DOE	129,023.00
Net Cost to U. of A.	$ 143,437.00

It was originally estimated that the hydronic economizer could produce 2,000,000 ton-hours annually, but the cooling tower performance at low ambient dry-bulb temperatures is less than anticipated. The approach to the wet-bulb is fourteen degrees Fahrenheit at these conditions, rather than the ten degrees Fahrenheit approach we expected and which is obtained at summer conditions. The approach through the heat exchanger is 1 to 1½ degrees instead of the 4 degrees expected. The net effect is to reduce the available operating hours, and the simple payback is increased from the estimated 1.7 years. Of course, as the cost of electric power goes up, the payback period decreases.

Last winter, our plant manager instituted a procedure for blending water from the heat exchangers with that from a chiller, and determined through experimentation that he could utilize 58 degrees Fahrenheit water from the heat exchangers. This requires rather close monitoring of the return water temperature from the campus.

The 58 degree Fahrenheit water can be obtained with cooling tower water at 56½ degrees Fahrenheit, which in turn is obtained at 42½ degrees Fahrenheit, wet-bulb ambient temperature. This procedure allows the use of the heat exchangers for a much greater time, and has reduced the cost of chilled water production significantly.

The history of our operation is shown in the following table:

	1980/81	1981/82	1982/83
Ton-hours Produced	657,662	635,625	1,300,000
Hours of Operation	982	939	2,104
Power Cost, $/KWH	.0472	.0472	.0502
Avoided Cost	$ 9,999	$11,870	$23,576

The experience in operating the hydronic economizer during the first winter was utilized in the selection and specification of a new three-cell cooling tower to replace three small deteriorated and obsolete cooling towers. Summer and winter conditions were considered, and performance at both conditions was specified as shown.

	Summer	Winter	
GPM	16,200	7,500	7,500
Entering Water Temperature, Degrees Fahrenheit	95	56	60
Leaving Water Temperature, Degrees Fahrenheit	85	46	50
Wet-bulb Temperature, Degrees Fahrenheit	76	37	41

The new tower was placed in service in May of this year.

National Weather Service records from Tucson show that the wet-bulb temperature is at or below 42 degrees Fahrenheit, original design wet-bulb temperature, for 824 hours each year; while it is at or below 43 degrees Fahrenheit for 2,042 hours each year. If we can raise our usable wet-bulb temperature to 48 degrees Fahrenheit, we are at or below if for 3,581 hours each year, or 40 percent of the time. We estimate that since we can utilize the 43 degree temperature most of the available time (2104 hours utilized last year, compared to the average of 2,042 hours available), we can expect to utilize over 3,000 hours each year with the new tower. This should increase the avoided cost by about one-half, to about $35,000 annually.

The most significant aspect of the technique is the production of chilled water without operating a chiller during four months or more during the winter.

The life of the installation is expected to be at least twenty years, which is normal for passive heat exchangers and associated piping and valves. The pumps and cooling towers of existing chiller systems are utilized. While the cost of pump and fan operation must be considered when comparing cost of operation, the pumps and fans are not considered to be added equipment. No spare parts are required, and with reasonable water treatment and the nature of plate-and-frame exchangers, little or no cleaning or other maintenance is anticipated.

In the summer of 1982, after two full seasons of operation, two of the heat exchangers were disassembled for inspection and cleaning. The condition was so good that it was decided to delay inspection of the other two for at least two more years. A slight, thin yellowish film was found on each side of the plates. The film brushed off easily, and the gaskets were in excellent condition. When returned to service, the difference in performance as read on the thermometers having 1 degree Fahrenheit scale divisions was less than ½ degree Fahrenheit between the exchangers which were and were not cleaned.

Another form of hydronic economizer which utilizes cooling tower water directly in the chilled water system was rejected because of the differing water treatment requirements for the open cooling tower circuit and the closed chilled water circuit, along with the chance of fouling the extensive and intricate chilled water system with its many control valves and water-to-air coils. These disadvantages were believed to outweigh the elimination of the small temperature difference required by the heat exchangers. Intermixing or cross-contamination between the open and closed circuits is unlikely, since any gasket leakage occurs to the outside of the unit.

The system has demonstrated economic feasibility, even though the operating limits found by experience are different from what was anticipated. We are looking forward to next winter's operation with the new cooling tower. The closer approach to ambient wet-bulb temperature, and the utilization of warmer chilled water from the heat exchangers by the blending technique, should improve the plant operation even more.

Grounds Management:
New Ideas in the Field for 1983*

By Ricks H. Pluenneke, Ph.D.
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Innovation is essential to the survival of industry and institutions, but it's important that it "makes sense" and fills a need, helping us to do a job better and more cost effectively. Similarly, it's important in grounds management. In fact, grounds management has become increasingly more technical in recent years. Grounds personnel are constantly handling sophisticated equipment and chemicals. Either one can quickly get them into trouble through misuse. The development of the nylon cord edger was an important innovation and an effective time saver. However, that same piece of equipment can quickly strip the bark and cambium from a young tree or shrub as an unskilled worker attempts to edge grass from around it. Automatic irrigation has given us a means to turn desert into luxurious landscape, but it has also given us a means to over water, drown tree roots, affect foundations and run up the water bill excessively if the operator isn't careful.

Through The Plant Pro® Advisory Service, I function as a "Technical Right Arm" to management and maintenance, conducting regular inspections of grounds and important landscape areas and providing reports to management regarding problems and potential problems that may exist. I also conduct training sessions and help evaluate new techniques and products. As a result, I am constantly monitoring new approaches from industry, universities and government. We have test plots on many accounts where new plant materials, fertilizers and other items can be examined in a "show and tell" type approach. There's nothing like seeing an approach applied to your own land under your own weather conditions and management program in order to reach conclusions about it.

Because of my involvement with innovations, I have frequently been asked to give talks on them. I have tried to include some from industry, some of our own and some from other grounds professionals; particularly at universities. I would like to cover a number of them with you here today. Bear in mind that a particular innovation to one of you may be "old hat" to another. If you can pick up one or two new ideas to take home with you today, I will have accomplished my goal. Also, all innovations don't come out of laboratories. I am particularly interested in innovations that our own professionals come up with. A tip on a little easier way to sharpen mower blades, how to keep up with inventories better. Perhaps a unique way to motivate employees. In some cases I will cover items or products that should be better known. If you would like further information on any of them, feel free to ask for further information or give me a call.

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*[Ed. Note: This paper was not presented at the annual meeting due to author's illness.]

The Plant Pro® Advisory Service

The Plant Pro® Advisory Service is something of an innovation in itself. I'm not aware of a similar service. We also review landscape plans from a "nuts and bolts" standpoint, heavy on the science and management side rather than aesthetics. New trees are inspected for potential disease problems that may be brought back onto campus. Nursery stock is checked for root bound conditions and soil tests guide fertilizer programs. We work hand in hand with landscape architects in team approaches on landscape designs. Our employees are required to sign an ethics agreement that puts the best interests of accounts first. Our main goal is to help accounts get the most from their money in materials and services.

The Professional Grounds Management Society

If your Grounds Superintendent is not a member, he probably should be. PGMS has been responsible for several of its own innovations. One of the most important has been the development of an outstanding certification program for professionals. Review materials and training sessions cover Principles of Grounds Management, Relationship Between Design and Management, Personnel Management, Financial Management; Turf, Ornamentals, Structures Management, Energy and Water Management, Environmental Issues in Grounds Management and other subjects. After successful completion of the two part program, the successful applicant becomes a Certified Grounds Manager. I've been involved with a number of certification programs, and this is one of the best that I have seen. The address for the society is: Professional Grounds Management Society, 7 Church Lane, Pikesville, MD 21208.

Tickler File

A 5x7 or 3x5 card file can be divided into months of the year. A card can be placed under January to remind you to order fertilizer and perhaps to run a soil test first. A card can be placed under May or June to remind you to spray MSMA herbicide for grassy weed control, and so forth. In grounds, we have to "temper" calendar schedules with constant weather observations, but a tickler box can help remind us to do things and can be improved upon each year. It's too easy to forget to order items in advance and it's easy to let a critical period pass by.

Infrared Aerial (Color) Photography

The technique has been used in agriculture for a number of years, and properly used, can often help us find underlying problems in landscape. This includes irrigation problems, hard pans, salt build-up and other soil related situations. In general, healthy vegetation appears red in the photos, and stressed areas appear pink to brown depending upon the degree of stress even though they may appear normal to the naked eye. A 35mm camera can be used from a light plane to ake the pictures. Roof problems may also be detected. The approach should not be confused with techniques used to determine heat loss from buildings. I usually recommend oblique shots for aesthetic purposes - ones that might look good enlarged and mounted on the wall and vertical shots for actual examination of the grounds.

Wiper Herbicide Applicators

For years we have depended almost entirely on sprayers for herbicide application, and often, up to half the spray drifts off target. This is particularly dangerous when sensitive landscape plants are nearby. Wiper applicators were developed by the USDA's Southern Regional Weed Laboratory and have proven themselves in both agriculture and urban applications. Some are hand-held, others are tractor and pickup truck mounted. Weeds can be killed over the top of desirable landscape plants. They are not intended to replace spray approaches, but to supplement them. You can build your own or purchase any of several on the market. Kits are also available.

Glue Boards

Baited with fresh peanuts, these boards can readily trap mice and offer another non-chemical approach to controlling rodents. Liquid adhesives are also available on the market to make your own glue boards. Other small animals may also be controlled with the technique. Glue boards are particularly helpful in areas where it would be dangerous to use poisons.

"Six Packs"

Plastic six pack holders for cold drinks can be used to hold up to six inexpensive, plastic sprayers. Each can be filled with a different herbicide, insecticide, etc. to conveniently carry in a work vehicle. Similarly, different solvents or lubricants can be placed in such sprayers for a six pack that's suitable around the shop.

Wildflowers

The use of wildflowers in landscape programs is very much 'in,' but we need to be sure they are used on sites where they belong or they may not do well and management problems could result. There are many species and we know little or nothing about most of them when it comes to their culture. Some hints: Be sure that leguminous wildflowers are innoculated when appropriate. Remember that high nitrogen fertilizers for lawns may inhibit flowering of wildflowers. Also, while you are trying to grow wildflowers, undesirable species may increase among them. Properly understood and used, they can offer additional color on compuses; particularly in outlying areas. Often it's not necessary to buy seed, but only to allow local species to express themselves. Beauty is truly in the eye of the beholder. Even daffodils can offer considerable color. Be prepared to allow the seeds on wildflower species time to mature. This means the plants will be dying and ugly for a few weeks, but it's normally needed to allow seeds to ripen for next year's crop of flowers. Also, the interest in wildflowers has resulted in many "instant experts," so be careful where you get advice. We often overlook expertise available in departments on our own campuses.

Native Plants

Native plants are also 'in,' but in fact, we have been using many for years. Clients usually ask landscape architects for evergreen plants (broadleafed or otherwise) so they can have green landscapes the year-round. But many of our native plants in Texas, for example, avoid drought and hard times by going dormant. This means they can often be expected to drop their leaves or to turn brown in summer. This is their normal way of getting around a problem, but it may be difficult to convince everyone, for example, that brown Buffalograss in August is beautiful. Many of the landscape plants we have been using require considerable modification of the environment in the way of improved soil, irrigation and intensive management. They are beautiful but often expensive to maintain. Frequently, we attempt to use these high maintenance plants all over our campuses. In the future, I expect the two approaches to be blended. The use of high maintenance plants in key areas only and lower maintenance native plants in outlying areas. Drip irrigation will probably be used more for irrigation, except where high maintenance turf is needed, but for many applications, drip irrigation can be regarded as still in the developmental stages. It's not without problems.

Three Wheelers

Three wheel, all terrain cycles (ATC) were first mass marketed by Honda, but most of the major motorcycle companies have at least one model now. Cost-wise, they range from around $600 to $2,000 per machine. They are finding even more use as work vehicles than as recreational ones. Trailers, boom spray rigs, fertilizer spreaders, mowers and other equipment are being adapted to them. I am aware of several locations where they are being used for trash pick up. Some models are exceptionally powerful. At least one has a reverse and another has a differential that allows for smoother turns. I would look for many improvements in the next two to three years because competition really didn't exist in the market until recently. I have been using them to inspect campuses now for over seven years. They are generally less expensive than some of the other grounds vehicles currently in use and normally weigh less than 500 lbs., but they also have their disadvantages. One is simply that the tricycle configuration is not as stable as a four wheeled vehicle.

Integrated Pest Management (IPM)

Often referred to as a new "buzz word" for an approach that many of us may have been practicing to a degree, for years. IPM has come into its own. It's a hybrid approach to managing crops and vegetation. It requires management to have a good knowledge of pests, vegetation and the environment, and blends biological, chemical, and cultural methods of control together. By simply avoiding the use of a plant species that local insects feed on, you are practicing IPM. When you remove bagworm bags from shrubs during winter, you are practicing IPM. Eggs will hatch in many of them if they are left until spring. IPM certainly makes sense, but requires grounds management personnel who are technically competent. As might be exptected, the approach began in agriculture and has resulted in the proliferation of a new specialist - the agricultural consultant. Today there are thousands of agricultural consultants across the country. Most have at least master's degrees, and many have doctorates. They function as "Technical Right Arms" to farmers and ranchers can be seen riding dirt bikes and three wheelers across fields as they monitor insect, disease and other potential problems. We perform the same service on campuses.

Your grounds give visitors the first impression they have of your school when they arrive, and the last they have when they leave, so their significance shouldn't be underestimated. Landscape has both functional and aesthetic values. Vegetation can buffer against sound, heat and cold. But it needs to be better understood.

These are but a few of the subjects that have been covered. If you know of one that should be included in future talks, please let me know. Thank you.

Developing an Engineered Plan for Managers

by: Michael F. (Mike) Baber, P.E.
Baber Engineering

I. WHY AN ENGINEERED PLAN

All of us - Building and Plant Engineers, Directors of Buildings and Grounds, Maintenance Department Heads, Directors of Housekeeping - all of us can be guilty at times of running parts of our departments "by the seat of our pants," without adequate paperwork or management systems. This is partly because we "came up through the ranks" and know, or think we know, everything that needs to be known to run our departments.

The purpose of this paper is to remind us of a number of steps we should take and systems we might develop to insure that we are operating efficiently and professionally. It also presents in detail an actual Engineering Analysis which was performed for a large school system. This particular analysis was performed for housekeeping, but many of its principles are applicable to other areas of maintenance as well.

A small department will not need all the systems and documentation presented. However we all must be concerned with the activities represented by the 25 steps. The list serves as a checklist of what we can do and how we can do it.

A. Objectives

The overall objective of developing an "engineered plan" is to establish workable management and maintenance systems, and train employees in their use so the department manager will manage the department rather than have it manage him/her. The following are sub-objectives:

1. Determine with upper management overall department objectives and desired levels of maintenance.
2. Prepare job results descriptions at all levels so the department manager and others will know precisely what is expected of them.

3. Prepare and implement appropriate procedures and methods combined with quality products, equipment and supplies.

   These should result in:

   - improved levels of maintenance
   - longer lasting, trouble free equipment
   - more effective use of personnel
   - reduced costs.

4. Establish a professional management system, with appropriate records.

5. Train the manager, supervisors and workers so they use where appropriate good and effective

   - management tools and procedures
   - principles of supervision
   - operating and maintenence procedures
   - training methods.

6. Schedule workers efficiently.

7. Establish a positive atmosphere under which the department deserves support from upper management, and gets it; and under which employees are motivated to perform their jobs with pride. This should result in retaining good personnel and in reducing turnover and absenteeism.

8. Establish effective communications throughout, especially between the department manager and upper management, other department heads, supervisors and workers.

9. Manage the department so as to meet budgets and clearly inform upper management of discrepencies between desired standards and performance allowed by the budget.

B. Benefits

The following benefits should result to the organization, the department, the manager and the employees:

1. Informed management with information to judge the effectiveness of the maintenance department.

2. Trained Department manager who manages the department rather than it managing him.

3. Trained supervisors and employees.

4. Motivated employees.

5. Workload divided fairly between employees.

6. Improved communications throughout.

7. Costs - you know what they are and where they are going.

8. Improved work procedures.

9. Reduced costs relative to work performed.

10. Higher productivity.

11. Increased cost-effectiveness.

12. Professional management applied to maintenance.

13. Using modern & efficient equipment, products & methods.

14. Equipment maintained properly.

15. Control over purchasing, product use & inventories.

16. Better maintained facilities.

II. THE ENGINEERED PLAN

Presented below are (a) the 25 steps to the development of the total plan, (b) a real example of an engineering analysis which was performed for a large school system, condensed of course and with names changed, and (c) some principles of management which will help any manager to be more effective.

The 25 steps are presented as if a manager were evaluating his/her department starting from scratch.

A. Developing the Engineered Plan

1. Objectives determination - Meet with and clear objectives, desired level of maintenance, and department policies with upper management. Prepare job results descriptions for all managers, supervisors and clerical personnel.

   Documentation

   - Statement of overall objectives and desired level of maintenance
   - Policy memorandum
   - Job Results Descriptions (see Figure 1. for a sample)

Figure 1.

JOB RESULTS DESCRIPTION

MAINTENANCE MANAGER

Major Goal: To operate a professionally managed and smooth running department which achieves the desired level of maintenance in the institution at reasonable costs.

KEY RESULT AREA #1. To have and properly maintain appropriate cost and cost-saving maintenance equipment.

Performance Standards:

The job of Maintenance Manager in the area of maintenance equipment will have been satisfactorily performed when:

1. He has determined that the equipment his department is using is adequate to perform needed results.
2. He has proposed to upper management any further purchases of equipment which can significantly lower his departmental costs.
3. The location of all department equipment is known and registered on an equipment log.
4. All equipment is properly cared for and maintained, and there exists and is used an equipment inspection/maintenance register.
5. All appropriate personnel have been trained on the proper use and maintenance of the equipment they use.

KEY RESULT AREA #2. To implement an effective purchasing, inventory control and product evaluation system.

Performance Standards:

The job of Maintenance Manager in the area of purchasing, inventory control and product evaluation will have been satisfactorily performed when:

1. The department is using a purchase order system and is keeping an up-to-date chronological purchases list. (etc.)

The above format is continued for the following Key Result Areas:

3. Personnel
4. Personnel Management and Supervision
5. Methods and Procedures
6. Training
7. Work Performance and Quality Control
8. Cost Control
9. Safety
10. Communications
11. Planning
12. Professional Self Development

2. Personnel files - Folder on each employee to include all pertinent data including commendations, reprimands, and job results evaluations (based on job results descriptions)

   Documentation

   - Personnel folders

3. Work order system - Manual or computerized system (see step 16.) for handling work orders. Documentation shown is for one manual system.

   Documentation

   - S.O.P.; maintenance work order request
   - Maintenance work order request
   - S.O.P.; maintenance work order log
   - Maintenance work order log
   - Maintenance periodic log sheet

4. Problems/Opportunities file - As ideas regarding problems and opportunities come up, which are not acted on immediately, these are written down and filed for later review in a folder, or folders by type.

   Documentation

   - Problems/Opportunities folder(s)

5. Time management review - All managers, supervisiors and clerical personnel keep record of how work time is spent for one week. This is analyzed to determine how each can manage time more effectively. Concentrate on reducing non-productive time.

   Documentation

   - Reports of how time spent

6. Daily record of accomplishments - This is a record which is completed daily by everyone except maintenance craftsmen and housekeeping and grounds workers. This includes managers, supervisors and clerical personnel. The report is a short list of major accomplishments or time-consuming tasks performed during the day. An analysis of these indicate who is getting results and who is just putting in time.

   Documentation

   - Daily record of accomplishments

7. Periodic objectives and results against objectives - On a monthly (or other periodic) basis each manager and supervisor sits down with his/her supervisor and establishes objectives for the coming period. At that time they review results against objectives established for the prior period, which is written on the same form.

Documentation

- Periodic objectives and results against objectives form

8. Shop & maintenance equipment evaluation - All shop and maintenance equipment (not tools & supplies) to be registered in a log along with pertinent data such as purchase date, supplier, type & who assigned to. Equipment to be inspected regularly & maintained according to manufacturers' specifications.

Documentation

- Shop & maintenance log
- Equipment inspection/maintenance register

9. Assignment of personal tools and equipment - Each employee signs out and is responsible for tools and equipment kept with him/her on the job for their personal use.

Documentation

- Personal tool and equipment log

10. Product & suppliers - Evaluate and test products, tools, supplies and equipment compared to other available items as advisable. Look into reputation and past and proposed contribution by suppliers. Obtain product/supplier performance history from maintenance staff.

Documentation

- Approved list of suppliers, supplies, tools and products

11. Inventory control and purchasing system - Establish system as appropriate to give information desired. Establish purchase order system if one does not exist. Can keep record of all products & supplies drawn by each employee for later usage analysis. Locate adequate storage area and arrange supplies in logical order.

Documentation

- Inventory control and purchasing records & reports
- Chronological list of purchases
- Maintenance product/supply usage record

12. Department communication & incentive program - Establish a program whereby manager and supervisors meet regularly with workers for information give and take. Manager to visit workers on the job on occasion. Consideration given to an incentive program such as "Maintenance Employee of the Month."

    Documentation

    - Plan of effective communication & incentives

13. Inter-departmental communication program - Schedule formal or impromptu meetings with all other department heads and personnel as appropriate.

    Documentation

    - Inter-departmental communication checklist

14. Engineering analysis - This can be performed for scheduling housekeeping, and for perpetual grounds and maintenance tasks. A real life example is presented in section II.B.

    Documentation

    - See section II.B.

15. Preventative maintenance system - This can be established manually or on computer and is beyond the scope of this paper. See step 16.

    Documentation

    - Beyond the scope of this paper

16. Computerized real-time reporting system - This of course is optional and is beyond the scope of this paper. Such a system would generate computer reports as desired, breaking out work to be performed, work completed, and costs by - employee - or building (or area) - or type of maintenance - or classification of maintenance - or cause of maintenance - and/or by date.

    Documentation

    - Computer input documents and output reports

17. Implement new staffing assignments, procedures and job assignments - Thoroughly train supervisors on changes and new assignments. Have supervisors introduce and train employees. Maintenance manager to follow up to insure adequate introduction and training.

Documentation

- Training reports

18. Management and supervision training program - Series of training seminars on the management system and on leadership, management and supervision skills. Training sessions followed by use on-the-job and reporting of results. Maintenance manager and supervisors to attend outside seminars if applicable.

Documentation

- Management principles list
- Records of training received

19. Technical training program - Training of supervisors on maintenance methods and procedures. Supervisors to receive instruction on teaching methods and training employees on a group and individual basis. Consultant or maintenance manager to follow-up by holding questioning sessions with employees. Consider developing formalized training orientation for new employees with tapes, slides, exams, and perhaps video tape.

Documentation

- Maintenance principles list
- Training program for new employees

20. Scheduling personnel - Schedule available personnel into job assignments, taking into account vacations, possible absences due to sickness, etc.

Documentation

- Monthly and daily work schedules (See 3. for work orders from work order system)

21. Inspection program - Regular inspection of work areas by supervisors and manager, using "inspection checklists;" combination of cursory and thorough inspections of selected limited areas.

Documentation

- Inspection checklists

22. Cost analyses for manpower and products - Can include analysis of where labor hours and product $ were spent, why, and total costs per project per job. (See step 16.)

Documentation

- Cost analysis forms

23. Review performance against budget - Either determine how to stay within budgets or inform management clearly why this cannot be done.

Documentation

- Budget

24. Procedures manual - Prepare procedures manual for department by compiling appropriate documents listed in this "engineered plan."

Documentation

- Procedures manual

25. Complete review of the engineered plan - On a regular basis (perhaps bi-annually) completely review the engineered plan, including schedules, job assignments, training methods, procedures, products used, etc. Refer to the problem/opportunities file. Search for changes which could have a large effect in reducing costs or increasing productivity. Discuss ideas with competent managers from other institutions.

Documentation

- Ad hoc report

B. Engineering Analysis

A housekeeping engineering analysis of a large school system was performed to determine

(a) what rooms and areas needed cleaning,
(b) how often they should be cleaned (frequency of cleaning),
(c) the time required to clean each room or area,
(d) the number of cleaning personnel required, and
(e) how the rooms and areas should be scheduled, and assigned to those personnel.

The steps performed in the engineering analysis and the results therefrom are explained below and are shown on Tables I-VII.

1. Room/Area map

Table I shows the map or floor plan of the school system with most rooms and areas listed. Note: only a small area is shown and is reported on for the purpose of this paper.

2. Room/Area listing

The school system was walked through and all rooms and areas to be cleaned were listed as shown on Table II, along with the estimated dimensions and areas of each.

These were listed in the approximate order that they would be cleaned as one would proceed through the building. Rooms were listed seperately from corridors, stairwells, etc., as different personnel would be assigned to clean them.

3. Time assignments to rooms and areas

Table III shows where the rooms and areas were again listed along with the time required to clean them, plus other related information.

Daily, non-daily and accumulated (or total) time is shown in Table III. The time required to clean the room or area each day was determined from a combination of industry standards, and from analyses and time tests performed jointly by Baber Engineering and other appropriate personnel.

The non-daily time is time spent in "thorough cleaning" or "detail cleaning". This is performed only once, twice or four times a month on a scheduled basis. (The schedules of "thorough cleaning" are shown in Tables V - VII).

The estimated square footage of rooms and areas are shown.

Footnotes give explanations of terms and assumptions.

Each room or area was assigned a number for later reference.

Also in Table III the particular job or position which was assigned to clean each room or area is designated by letter code. The assignment of rooms and areas to jobs was made during preparation of Table IV.

4. Work assignments by position

Table IV show the results of the work assignments by

Table I

Floor Plan

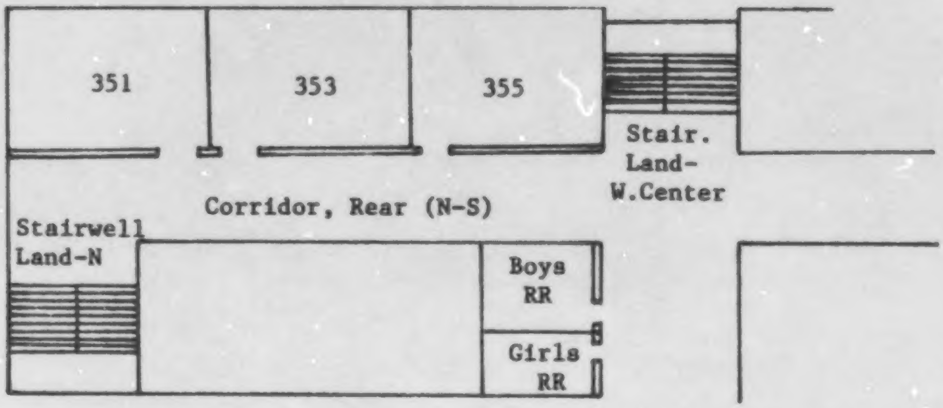

Table II

Room/Area Listing

Room/Area	Dimens	Sq. Ft.
Room 351 - Sculpture	24x29	700
353 - Music	24x29	700
355	24x29½	710
RR - Boys (4 Fix)	15x15	230
RR - Girls (2 Fix)	10x16	160
Stairwell Landing - N (Terrazzo)	13x26	340
Corridor, Rear (N-S)	11x256	2820
Stairwell Landing - W. Center	14x24	340

Table III

Time Assignments to Rooms & Areas

	Fixt.or	Cleaning Time				
Room/Area	Sq. Ft.	Daily	Non-Daily	Accum	No.	Job
Room 351 - Sculpture	700	45(1)**	2.3(2)	47.3	1	A
353 - Music	700	15(3)	0.8(2)	15.8	2	A
355	710	15	0.8	15.8	3	A
RR - Boys at 352	4 Fix	10	1.3	16.3*	RR-1	D
RR - Girls at 352	2 Fix	10	1.3	12.3*	RR-2	D
Stairwell Land - North	340	2(6)	0.4(7)	2.4	18	E
Corridor - Rear (N-S)	2820	12(8)	2.4(9)	14.7	19	E
Stairwell Landing - W. Center	340	3	0.6	3.6	20	E

* Includes 5 min. + 1 min. travel time, respectively

** Footnotes are explained at the end of Table III of the actual report.

position. The rooms and areas were assigned according to a logical work flow to the following job positions, for instance.

Job Pos.	Name
A	Classroom & Office Cleaner No. 1
B	Classroom & Office Cleaner No. 2
C	Special Projects Cleaner (assignments specified by supervisor)
D	Wet Cleaner No. 1
E	Corridor & Carpet Cleaner No. 1
F.	Cafeteria & Kitchen Position
G.	Gym Position

In addition to positions A-G (etc.) who work in the evening there are additional day positions, plus day supervisors. These latter positions handle daily checking of restrooms, dust mopping of corridors, spot removal of graffiti, plus other duties as assigned. These include locking the building, setting up chains and stop signs, and replacing light bulbs.

Table IV shows the rooms each position cleans on a daily and non-daily basis, in the order of cleaning, with the total time of daily-plus-non-daily cleaning. Each person was assigned approximately 7 hours, or 420 minutes, of work each day. This leaves one hour on an 8 hour shift for preparation, cleanup and breaks. Travel time is included in the assigned cleaning times.

Table V contains the basic work document for each position.

Tables V - VII show the scheduled thorough cleaning time and when it is to be performed, for each room and for each position.

The work was assigned so all the cleaners in a certain classification(C&O, WC, C&C, etc.) move to the floor below at the same time. This gives the supervisors more control, as they should know where each cleaner is at all times and what room or area he/she is scheduled to move to next. As explained later it also provides energy savings.

5. Position work schedule

Table V shows for each position the rooms and areas to be cleaned each day, in the order of cleaning. This is theoretical and will be adjusted somewhat by daily conditions such as special classes and scheduled evening classes.

Table IV

Work Assignments by Position

Room/Area	Number	Time	Accum.
351	1	47.3	
353	2	15.8	
355	3	15.8	78.9
Boys RR at 352	RR-1	16.3	
Girls RR at 352	RR-2	12.3	107.5
Stairwell Land - N	18	2.4	
Corridor - Rear (N-S)	19	14.7	
Stairway - W. Center	10	3.6	128.2

The daily cleaning time is shown for each room. Then the frequency of thorough cleaning is shown (say every 4 weeks) along with the time required for thorough (extra) cleaning (say 45 minutes), and the average additional time that the thorough cleaning will consume (say 2.3 min/day). This (2.3 min.) was added to the daily time (say 45 min.) to total the total average time (say 47.3 min.). This total average time was used in Table IV to determine which rooms/areas to assign to each employee.

6. Thorough cleaning analysis

In Table VI the time specified for thorough or detail cleaning in Table V is assigned by day.

For instance, for room 351 the 45 minutes of thorough or extra cleaning time is spent at 7 minutes per day for days 1-6.

In other words, the person holding classroom and office position No. 1 will spend 45 plus 7 or 52 minutes cleaning classroom 351 for days 1-6. On days 7 & 8 he/she will spend only 45 minutes cleaning room 351 and 15 plus 7 or 22 minutes cleaning room 353. The extra time will be spent cleaning edges and corners, behind radiators, high dusting, spotting walls, etc.

7. Thorough cleaning schedule

Table VII shows a simple schedule of thorough cleaning that the cleaner can understand more easily.

The worker should be given a copy of Tables VI and IV for his position. Tables VI and V are available if they would be helpful to the worker.

8. Energy conservation

One of the side benefits of the engineering analysis resulted in considerable conservation of electrical energy.

The program was designed so all cleaning personnel started on the third floor. In approximately two hours, all cleaning on the third floor is completed. Then all lights can be turned off on the third floor.

The team then proceeds to clean the second floor, turn off all lights, and to finish up on the first floor.

9. Supervisor

Table VIII outlines the suggested responsibilities for the custodial supervisor.

Table V

Job Position Schedule*

Floor	Room/Area	Daily Time Min	Thorough Cleaning Wk. Freq.	Thorough Cleaning Extra Time	Aveg.Time Per Day	Total Aveg. Time, Min.	Job
3	351	45	4 wk.	45.0	2.3	47.3	A
	353	15	4 wk.	15.0	0.8	15.8	A
	355	15	4 wk.	15.0	0.8	15.8	A
	Boys RR at 352	10 + 5**	1 wk.	6.5	1.3	16.3	D
	Girls RR at 352	10 + 1	1 wk.	6.5	1.3	12.3	D
	Stairwell Land - N	2	1 wk.	2.0	0.4	2.4	E
	Corridor - Rear (N-S)	12	1 wk.	12.0	2.4	14.7	E
	Stairwell W. Center	3	1 wk.	3.0	0.6	3.6	E

* In the actual Engineering Analysis all the areas for each job are listed seperately and in the order cleaned for Tables IV, V, VI & VII.

** Travel Time

Table VI

Thorough Cleaning Analysis

Classroom & Office Position No. 1 (Job A)

Floor	Room/Area	Daily Time Min	Thorough Cleaning Wk. Freq.	Thorough Cleaning Extra Time	Days Scheduled	Time Min.Per Day
3	351	45	4 wk.	45	1-6	7
	353	15	4 wk.	15	7-8	7
	355	15	4 wk.	15	9-10	7

Wet Cleaning Position No. 1 (Job D)

Floor	Room/Area	Daily Time Min	Thorough Cleaning Wk. Freq.	Thorough Cleaning Extra Time	Days Scheduled	Time Min.Per Day
3	Boys RR at 352	10 + 5**	1 wk.	6.5	Mon.	7.4
	Girls RR at 352	10 + 1	1 wk.	6.5	Tues.	7.4

Corridor & Carpet Position No. 1 (Job E)

Floor	Room/Area	Daily Time Min	Thorough Cleaning Wk. Freq.	Thorough Cleaning Extra Time	Days Scheduled	Time Min.Per Day
3	Stairwell Land - N	2	1 wk.	2	Tues.	2
	Corridor - Rear (N-S)	12	1 wk.	12	Mon.(Tues.)	8.6(4)*
	Stairwell W. Center	3	1 wk.	3	Tues.	3

* 8.6 Min. extra on Monday & 4 minutes extra on Tuesday.

** Travel Time

Table VII

Thorough Cleaning Schedule

Classroom & Office Position No. 1

Floor	Day	Room/Area	Time
3	1-6	351	7
	7-8	353	7
	9-10	355	7

Wet Cleaning Position No. 1

3	Mon.	Boys RR at 352	7.5
	Tues.	Girls RR at 352	7.5

Corridor & Carpet Position No. 1

3	Mon.	Corridor Rear (N-S)	8.5
	Tues.	Corridor Rear (N-S)	4.0
	Tues.	Stairwell Landing - N	2.0
	Tues.	Stairwell - W. Center	3.0

Table VIII

Building Housekeeping Supervisor

Job Responsibilities*

- Screen new Employees
- Train new Employees
- Train established Employees - increased performance
  - safety
  - refined methods
- Make job assignments
- Inspect all work regularly
  - Review inspection results with workers
  - Show how to achieve improved results
- Review time allocation with workers
  - Suggest improvements in time allocation
  - Establish priorities
- Communicate regularly with administrative personnel
  - Learn of work deficiencies - Take care of
  - Learn new priorities - Establish
  - Learn work requirements - Accomplish
  - Communicate an attitude of cooperation and results orientation
- Communicate regularly with all Employees
  - Give appreciation and encouragement
  - Test their knowledge and attitude
  - Ask how you or the administration can help them do a better job - What is needed
  - Show an interest in them and their lives
- Open the building and perform other scheduled and unscheduled duties. Make a written list of these.
- Manage housekeeping equipment
  - Record all equipment
  - Assign a storage location for all equipment
  - Periodically check the location of equipment
  - Obtain an equipment maintenance procedure
  - Arrange regular maintenance of equipment
- Operating supplies and chemicals
  - Record usage of supplies and chemicals by worker, and total usage
  - Keep supplies in stock by timely checking, ordering and receiving
- Prepare and/or give written job schedule to each worker, including important cleaning points.
- Arrange proper equipment, supply and key set-up so employees can go to work immediately at starting time.
- Arrange and make regular, unscheduled checks on worker location and work accomplished.
- Establish and use a problem/opportunities file.
- Continually improve your knowledge of cleaning technology, and management and supervision principles.

* Note: These can be delegated, but not abdicated.

C. Management and Productivity

The following are two concepts of effective management which are suggested for inclusion in step 18 of the management plan.

1. Effectiveness and productivity

The effectiveness and productivity of our people is in direct proportion to their belief that the work is - worthwhile - important - timely - beneficial (to themselves) and doable. The responsibility of a manager or supervisor is to convince his/her people of each as follows:

(1) Worthwhile - by communicating how the work fits into the overall institution objectives and how and why both are of value from a humanitarian standpoint. It may be obvious to the manager but not the worker as to why the work is "worth doing at all."

(2) Important - by communicating how the work fits into the overall institution objectives, how the institution will benefit as a result of high quality work performed efficiently, and how the institution really will suffer from poor quality work or high costs resulting from poor efficiency.

(3) Timely - by communicating why the work must be done now, or within the time specified, and what the harm will be if it is delayed.

(4) Beneficial - by determining what the employee wants and needs as a person, and by showing him/her how they will receive what they want and need by performing the work well and efficiently. In other words, to determine "what's in it for them" to work hard and smart, and to motivate him/her by understanding them and by using proper management methods.

(5) Doable - by giving the employee proper skill-training so he/she knows how to do the work well and has the self confidence to attempt it. And then by encouraging them by using positive reinforcement, and making them feel good about themselves and feel that they can do the work with success and without failure.

2. Team leadership

The productive manager is a coach or team leader who is concerned both about the work (quality and quantity) and about his/her prople (and their wants and needs).

The productive manager leads his team effectively by:

(1) Knowing the job he wants them to do, and how he wants them to do it,

(2) Listening to his employees,

(3) Knowing his people by communicating with them and understanding their wants and needs,

(4) Emphasizing growth of his people in the present job so they can receive both job satisfaction and rewards,

(5) Knowing and communicating to his people the race you want them to run - what should receive emphasis,

(6) Dealing with his people through specific and critical incidents rather than unprovable generalities,

(7) Stressing acceptance of his people and the work they do; looking for what they do well and telling them and others about it,

(8) Getting their agreement on any changes you want them to make in their performance or behavior, and

(9) Setting up timetables for objectives to be accomplished.

III. WHAT NOW?

By comparing the performance and management systems of our departments against the 25 steps in the "engineered plan," we can determine where we can strengthen our own management systems.

There are two ways we can approach applying this Engineered Plan to our department.

First, we can start with step one and implement each step in order as needed by our department. Second, we can review the entire list and choose the step we should take first, which is most important in achieving the objectives of our department. After taking that step we can then select the second most important step.

Either way, we move forward toward our goal of becoming an even more professional and effective manager. As a result everyone benefits - our organization, our people, our department, ourselves - everyone.

Wednesday, July 13

LOUISVILLE,
KENTUCKY

APPA
'83

Positive Retrenchment--What An Opportunity

By Roger C. Allen
Central Michigan University

My mission this morning is not necessarily to share anything new in the battle of the budgets, but rather to re-hash some of the things we already know and present them in a more positive manner. There is no doubt we will survive the latest round of budget reductions, but can we do it in a positive manner? I strongly believe we can and as a result will be better managers for it. It has been said, "A jackass can kick down a barn, but it takes a good carpenter to build one."

People are geared to managing in times of growth, with few liking the times of decline, but both periods can be exciting opportunities. Through the ages, times of turmoil and stress have also proven to be times of ingenuity, invention, and progress. Granted when your president or vice president, as the case may be, contacts you and says we need another ten percent reduction in the Physical Plant budget, your first thought is likely not very positive. In fact, if they could read your mind, they are already climbing into that fire retardant suit for a trip to a warmer climate. Think about that request for a moment, it is not the end of the world. If they want a ten percent reduction that means you get to keep ninety percent.

How often have you seen those glaring headlines, "Unemployment 10.2% in the United States." I wonder why it couldn't be just as easily written, "Employment in the United States is almost at the 90% level." Maybe I'm just being naive, but in my mind ninety percent of anything is quite good. Perhaps the first thing we should do when getting that request for a budget reduction, is to remind ourselves as to why we are here. Stated very simply, Physical Plant is responsible for the construction, renovation, maintenance, repair and operation of buildings, facilities and utility systems. We are a service concern. Nowhere does it say we have to raise funds to operate our department. That job belongs to higher administration, politicians, and the bean counters. Now I'm not forgetting that we are constantly doing audits and making application for the many and varied grants available, but the basic fact is, we depend on others for funding our operations. The services provided by our department are directly related to the resources available to us and our ability to manage those resources. Since we have little control over the acquisition of resources, we should concentrate on our primary function, managing those resources in which we do have control.

My experience at several institutions over these past seventeen years, has made one thing very clear to me; no matter how well we think our operations are running, there is still waste and considerable room for improvement.

Now notice that I haven't even considered the fact that your president or vice president might have said, "Plant Administration, reduce your supply budget, your equipment budget, eliminate the apprenticeship program, and all travel in your department, to come up with the ten percent of your total budget as a reduction." There are without doubt, people in our business who did not make this meeting today because some short-sighted senior administrator decided it wouldn't look good to have plant people traveling to a seminar in these times. It's always easier to reduce the supply budget than it is to reduce jobs, not wiser mind you, but easier. And I say these administrators should get out of the business, they are a menace.

Don't sell your future to save a few dollars today, but rather invest in your future. It is the only way to survive. No one at this meeting needs to be convinced of the importance in communicating with others in our business and of the challenges we face in trying to keep abreast of new technologies; but don't kid yourselves, there are those in places of influence who think otherwise. Our job is to convince them just how wrong they really are. Poor communications reminds me of the story about an old New Englander named Eb. Old Eb was like many of his breed, rather stingy with words. He said very little and then rather grudgingly. One evening he was sitting on the front steps with his wife, the long day's work, the good supper, and the peaceful sights and sounds of dusk must have softened him up. He took his pipe out of his mouth and said, "When I think of what you've meant to me, all these years Judith, sometimes it's more than I can stand not to tell you."

At our institution we were fortunate in that our leadership never lost sight of the future. They took the position early on that all staff reductions would be by attrition, rather than through lay-offs. Savings in approved positions which were vacant, were given to the departments for other uses. Staff reductions were not limited to those on the low end of the scale but included senior administrators as well. We were asked to provide our recommendations for reducing the budget, with clear definitions of the effect on the services we provide. With this kind of information they were able to make a decision on those reductions which would least affect the services we provide to the total campus. Along with this, other departments at the institution were asked to submit their ideas for budget reductions. There were of course the typical ones, reduce the grounds crew so that you only have one man per shovel, review the practice of employees playing golf matches or jogging during work hours. Needless to say, that one was close to home. But there were some very good ideas. These were compiled and after being reviewed by the vice presidents, copies were distributed to all departments for their comments and considerations. By the way, at our institution all departments not only Physical Plant were required to reduce expenditures to meet the budget reduction. And that certainly, as you might expect, went a long way toward keeping a positive attitude in the Physical Plant. Prior to providing our University officials with the information they needed to make the final decisions, we of course had a great deal of work to do.

As I cover some of the items in which we were able to reduce our budget, I would first like to give you a brief description of our institution. Central Michigan University is located in Mt. Pleasant Michigan on approximately 800 acres, with 3.8 million square feet of buildings and a student capacity of somewhere around 16,500. The Physical Plant operating budget is approximately $10 million: the budget break-down is approximately 53 percent personnel and fringe benefits; 13 percent supplies, materials, contractual services, and equipment; and 34 percent utilities. At Central Michigan University, budget reductions were not new to us and like many of you we took substantial cuts in 1974-75, with the latest round taking place in both fiscal year 1981-82 and 1982-83. Considering that we received no new monies for inflation, the total loss of operating funds for this latest reduction would equal something greater than ten percent. The Physical Plant budget reduction for our institution had to come from the operating budget minus utilities. Obviously the major amount had to come from personnel.

No one likes to be a part of anyone losing their job, but the hard cold facts were that it didn't make much sense to keep the employees and not have materials and supplies for them to work with. But then of course we come to a positive note, approximately one-half of our budget is derived at through auxiliary services. Since the residence halls remain full due to our ability to still attract student residents, the actual budget cut was not $1 million but rather $500,000.

As we studied the problem further, it was decided that all essential services needed to maintain the integrity of the buildings would not be considered for reduction until such time that all others were exhausted. Since custodial employees constituted the largest number and cost within our budget we recommended substantial cuts in those areas. Cleaning, especially in private offices, was greatly reduced. We now clean private offices two times per week which I've always believed was adequate with a little consideration by the user. You know I can equate that to our own home. Since my wife and I both work and the kids attend school we don't clean the whole house daily, she only makes me do it on weekends before golf.

Along with the reduction in office cleaning we reduced the relief pool substantially. In so doing, it brought to our attention that sick leave usage was way out of line, the only reason we needed a large number of relief employees to begin with. In addition, we found three positions charged to our account which basically did very little cleaning but were used in the Physical Education set-up to hand out towels. In case you're not familiar with what the Physical Education department does, they are the ones who hand out Doctor of Canoeing degrees at Commencement. Towel handling duties were reassigned to Physical Education Department employees who had plenty of time for these extra duties. Since we were given adequate time to prepare for the reductions in our staff we were able to prevent any lay-offs and handled all positions through attrition and of course the relief employees, who were part-timers with other means of income.

Our next priority was the moving crew. Although moving is a very necessary service for our institution, nonetheless, it is non-maintenance work. In reviewing work orders for a three-year period we found our crews providing such good service that the user department did very little if any planning; they left us with the responsibility of providing service at their beck and call, with little if any advance notice. By working with the departments we provide this service for, an understanding was reached that we henceforth would require one weeks notice for our services, otherwise it would have to be accomplished on overtime at their expense. We were able to provide the same service as before with one less employee out of a five person crew.

The third priority was to look at the grounds crew. By eliminating some flower and shrub beds, a reduction in fertilizing, using food service employees during the period May 15th through August 31st (who would otherwise draw unemployment benefits) to supplement our regular crew, and a somewhat slower response to snow removal we were able to reduce two positions. Yet we feel our campus is still maintained in a very satisfactory manner. Next, we looked at our central heating plant, which had been staffed for as long as anyone can remember with some eight employees and a supervisor. Since we burn natural gas as our primary fuel, with fuel oil as a stand-by, and our plant is quite well automated, it didn't make much sense to have on the average of two men per shift. Luckily at about that time, one operator retired and two others opted to move into other trades positions caused by retirements, thus allowing us to reduce the staff by three without causing a lay-off.

Now we had taken the easy ones but still required more. So it was time to look at those positions we heretofore had considered untouchable; namely, the trades (electrical, plumbing, maintenance mechanics, carpenters, painters). We have a deferred maintenance list like most, if not all of you, so to reduce this crew was not easy. Luckily over the years our Physical Plant leadership had made a conscious decision to maintain our full-time staff, somewhat on the lean side, with considerable money set aside for temporary employees to be used during the various breaks, especially during the summer break (May 15 through August 31st). To reduce this staff and still complete the necessary maintenance would require one hell of an increase in productivity, and you know that's not easy.

Anyhow, back to our work order records to analyze where the crafts time was being expended. Guess what we found? Fifteen percent of their time was spent doing non-maintenance work, such as remodeling. Equally as bad was the fact that 43 percent of all work accomplished was considered an emergency. Do it now. Further study showed that much of the emergencies were really not emergencies at all, but things like fluorescent lamp is flickering, garbage disposal in apartment doesn't work properly, shower drain runs slow, and on and on. Well I don't know about you, but none of the items mentioned so far fit my definition of an emergency. When the toilet backs up at the President's residence during an official party for the Board of Trustees, that's an emergency! In one year we reduced so-called emergency work orders by some seventy percent, with a resulting substantial increase in productivity.

The fifteen percent non-maintenance work amounted to 10,395 hours during 1981. A quick breakdown of actual available work time for our employees after deducting the gimies--vacation, sick, breaks, wash-up time, holidays, personal days, union meetings and training, meant that seven positions were being used for non-maintenance work in the trades area. It was very clear to us at that point, that if we reduced emergencies and non-maintenance work, we could in turn greatly reduce our temporary personnel budget for the crafts area and still provide adequate services to our buildings.

The institution still had to face the fact that at least some of the non-maintenance work was necessary. So a major decision was made. Since our regular staff was only adequate in size to perform necessary maintenance, all non-maintenance would need to be on a charge-back system until such time as we could reduce our backlog of normal maintenance work to less than eighty man hours per employee. Now I have heard all the horror stories about charge-back systems, ill will between Physical Plant and the departments you serve, deceitfulness, low productivity, various departments wishing to contract out their own work and on and on. Well let me tell you, if a contractor with the overhead they have, plus the need to make a profit, can accomplish work less expensively than you, your problems are one hell of a lot bigger than a simple charge-back system. Needless to say, our backlog continues to exceed the eighty hour criteria with non-maintenance work being accomplished on overtime or by contract, depending on the time available by our staff. Because we do not figure overhead in our overtime charge-back rates, our prices are still very favorable when compared to contract prices. Surprisingly enough the departments requiring non-maintenance work are, even in these times of declining budgets, able to come up with the monies to get their jobs accomplished if they are in fact necessary. Even more importantly, the demand for non-maintenance work was reduced greatly when the account director, rather than the secretary, made the decision as to whether a certain project was needed or not.

Other overtime in Physical Plant was greatly reduced and in some cases eliminated all together. All overtime, except that for emergency situations, requires the authorization of the Director of Plant Operations. Overtime is now limited to requirements of living spaces, safety and security of the buildings and grounds, or on a charge-back basis. Money producing events such as conferences and special events must include in their fees the cost for any additional service from Physical Plant, which is above and beyond normal maintenance service.

As we continued our study of the operations, we took a real strong look at administration and first-line supervision. First we looked at it realistically. Supervision, including ourselves, are non-productive. We do not produce any direct work other than perhaps, on a minimal basis, consulting work to our institutions. We are simply overhead when referencing productive work. Another way of putting it is we are a necessary evil. That should come as no surprise to anyone here. Hell the faculty have been telling us that for years. In times of growth, it is very necessary to add sufficient supervision to insure that the ship will stay afloat while everything in your operation changes daily. In times of retrenchment, it is equally important to take an honest look to see if those same numbers of supervision are still needed. In our case we found we were able to reduce our supervisory staff by one position with additional ones forthcoming through attrition.

If we are to be honest when assessing our supervisory staff needs, we must rethink our belief that employees do not want to work. Too many of us believe the only way we can insure a fair days work is to have a supervisor looking down their necks all day. Ninety percent of your employees want to work, and will probably do more, if you get off their back. Set the priorities, give them the necessary training and tools, and allow the ninety percent to do their job. Spend your time on the ten percent and try to overcome those bad work habits and if you can't, fire them before they affect the good workers. Remember there are very few bad workers, just bad managers.

Prior to recommending any of the above mentioned budget reductions, we made it a point to talk to the people involved, both those we provide a service for and our own employees. Some items which we originally had assumed to be non-essential turned out to be very essential and had to be removed from our list. Others were recommended by Physical Plant as well as the area being served and these were implemented. The important thing is that people who would be affected were involved in the decision-making prior to submittal of our recommendations to the vice presidents.

It is always a must to know your union contract, assuming you have one. Many of the routine workings of your unionized staff can easily become a nightmare with just one lay-off. We provide, as I am sure many of you do, work for our students. Our union accepts that fact and we are well covered in our contract with them. However, once positions are being eliminated watchout for the fireworks.

Implementation of our reduced services went quite well because people were informed. That's not to say there weren't those who conveniently forgot they were required to give us one week's notice for a special event set-up that they had likely known about for six months. We handled them in a very positive manner. Never did we or do we say, no we can not do such and such. What we do say is just give us your account number on a work request signed by the account director and we will see that the job gets done. On overtime of course. Now you can see we have brought to the attention of the account director that someone in their operation didn't plan, didn't do their job and I suspect it doesn't reoccur very often.

It's a well-known fact that everyone on campus knows more about how to run a Physical Plant than we do, and they certainly didn't hesitate to tell us that. But those in responsible positions, at least on our campus, well knew the problem with the institution's budget, since they were all involved, and they were very understanding. Because of this most recent budget reduction, we are leaner but still maintaining our buildings and grounds in a satisfactory manner, and have learned a great deal about ourselves.

Let's briefly go over the positive results from this experience. First, we communicated with all members of the campus community. We know them better, and we know what some of their problems are. They in turn have a better understanding of us and our problems. Someone once said, "There are no problems that we can't solve together and very few we can solve alone." Our employees are very aware that we made every effort to assure them that there would be no permanent layoffs and we were successful in making our staff reductions through attrition. We were able to show the top administrators that we could and did come through during hard times for all of us, and we provided them with positive choices, including good documentation for any reductions recommended, and in areas that would have the least negative effect on our institution.

Our custodial services, although limited, are still of a high level and most people realize now that perhaps some of the services they were getting were not entirely necessary. When we reduced the custodial relief pool, we were forced to take a hard look at sick leave misuse. As a result, we are working very closely with our staff to reduce misuse of sick leave in a positive way, but will take disciplinary action if necessary. Along with this, we are instituting a new light-duty custodial position for employees who would normally stay home and draw workmens compensation. We now fit a job to their limitations and pay for a temporary employee, out of compensation funds, to do their regular work. Since we are self-insured, the savings are substantial as you might expect. Our experience has been that if the employees have to work anyway, most find themselves in a very short time, ready and wanting to do their regular work.

Because our moving crew is now able to plan their work, for the most part, one week in advance. We are in fact doing more work with one less position, and the workers are far more satisfied. Our grounds are still being maintained at a very high level and we continue to work toward reduction of high maintenance areas. I might add that as soon as our Campus Beautification Committee moves closer to our way of thinking, life will be even easier.

Our central heating plant staff has handled the plant very well with these reductions in staff, with no noticeable changes in the operation. The fact is we planned to reduce the staff two additional positions and fully automate the plant when, low and behold, a new plan came into being. With the help of some creative financing from our Vice President of Business and a HUD loan, we are presently designing a Wood Chip Plant which will save us some $1 million in fuel costs the first year alone. Along with that, we will instead of reducing staff, actually start to add staff and train them to handle the new responsibilities.

With our reduction of emergency work orders not only have we greatly increased our productivity, but have a far happier work force because we have reduced their frustrations. They get to finish what they start without being interrupted for some make believe emergency.

Non-maintenance work, with the exception of moving and delivery, is just about one hundred percent on overtime or contract. Our crafts employees are given all of the overtime that they want. They do enjoy doing some of the special projects without having it interfere with the normal maintenance work, our primary responsibility.

Physical Plant administrators and supervisors, for the most part, are proud of what we were able to accomplish. They have renewed interest in their jobs and are eager to assume additional responsibilities and seek other ways to improve our operation. We are still looking toward consolidating additional administration and supervisory responsibilities, which gives our existing staff on an individual basis a chance to grow and for the University to reduce costs.

We are much more familiar with our union contract and are ready for the next round of negotiations to get some things changed which will further enhance our ability to be flexible when the time comes for still another change.

As I conclude my speech this morning, I would like to leave you with one thought. In these times when we are getting more and more of less and less, just know the answer to positive retrenchment is simple and available to each of us right on our own campuses. The key is communications with our total campus family and the many other resources at our disposal. Thank you.

"Performance Review - A Motivational And Evaluative Tool"

By William A. Custer
West Virginia University

OVERVIEW

One of the major responsibilities of Physical Plant administrators is the management of personnel. As budgets dwindle and campus responsibilities increase, the effective management of the Physical Plant work force becomes more and more critical.

An effective performance appraisal system makes it possible to evaluate individual employees strengths and weaknesses. In addition, appraisal also provides an excellent opportunity to motivate the staff to perform better. Regardless of an employees capabilities, there are always aspects of their jobs in which they could improve. The main purpose of the performance appraisal then, is to evaluate individual employee performance and to use their skills and deficiencies to motivate them toward improvement on the job.

[1]Performance evaluation or appraisal provides an employer with a method by which to measure the output of an employee. [2,3]It is primarily used as a motivational device and has been called the most needed and neglected supervisory tool.

PURPOSES

[4]There are four purposes for performance evaluation:
1) To communicate management goals and objectives to employees.
2) To distribute organizational rewards such as salary increases and promotions equitably.
3) To motivate employees to improve their performance.
4) To conduct personnel management research.

[5]Given that there are different purposes for performance evaluations, there are also a number of different types of evaluations:
1) Coaching Appraisal - The manager appraises the employees performance in an effort to guide his own actions to help the employee improve his/her performance.
2) Career Guidance Appraisal - The manager appraises the employees overall abilities in an effort to counsel the employee regarding career plans.
3) Salary Appraisal - The manager appraises the value of the results of the employee's work as a guide to recommending suitable salary action.
4) Promotional Appraisal - The manager appraises the ability of the employee to do the work for a better, open position.

PREREQUISITES

A prerequisite to an effective performance evaluation system is the establishment of performance requirements. [7]A performance requirement is a determination, mutually agreed upon by the supervisor and the employee, of acceptable performance for a given task or work operation.

The importance of performance requirements is easy to understand. Performance evaluation presupposes that there are standards of performance which are acceptable. The performance requirement outlines those standards and establishes the basis for performance evaluation.

It is important to realize that performance evaluation is not a one-time event. It is an ongoing system where performance is monitored continuously, however, the reporting of this performance is done on a formal, scheduled basis once or twice per year.

It is also important to understand that the benefits from a performance evaluation system come over time. The initial evaluation sets the stage and serves as a motivator. The success of the program is determined in the amount of progress made during the subsequent evaluation period.

[8]The greatest success will be realized if the supervisor applies the axiom that behavior that is rewarded will tend to be repeated and that if high performance is not rewarded it will not continue.

[9]The supervisor should strive to perform the following management concepts of good supervision daily.
1) Explain what is expected. (i.e. performance prerequisites)
2) Spotlight good work and correct poor work.
3) "Show and Tell" where improvement is needed.
4) Justify actions. (i.e. advise your employees about personnel decisions and the reasons behind them)

[10]A very important aspect of performance appraisal systems is the requirement that the evaluation is based on performance that is job related and must cover only what is important in the employees job.

The importance of job relatedness comes from legislation such as the Equal Rights Act of 1963, the Civil Rights Act of 1964, the Age Discrimination in Employment Act of 1967 and the Vocational Rehabilitation Act of 1973 amoung others.

[11]Griggs vs. Duke Power, a case settled before the U.S. Supreme Court in 1971, was a "landmark case in securing civil rights for all citizens". The case addressed the issues of job relatedness and discrimination and served as a catalyst for the development of affirmative action programs.

[12]The importance of these laws relate to "explicit or implicit sections that require employers to document employee performance before making various human resource-related decisions."

GUIDELINES

Although I will not endeavor to describe the implementation phases of a performance appraisal system, I will give some general guidelines which should be useful.

[13]The Ten Commandments of a Valid Performance Appraisal:
1) Performance appraisal policies and procedures must be complete, clear, consistent, and documented.
2) Records - usually completed appraisal forms - must be retained to provide evidence of appraisal judgments and the specific reasons for the judgments if they are challenged.
3) The work behaviors or outputs evaluated must be explicit, as objective as possible, and demonstrably job related.
4) The work behaviors or outputs evaluated must be formally reviewed periodically to ensure that they have not become irrelevant or obsolete.
5) The methods used to gather performance data must provide sufficient detail to ensure adequate evaluation of performance.
6) The technique used to develop performance measurements must be reliable and valid.
7) Provision must be made for initial and ongoing training of appraisers.
8) Appraisers must be given feedback and held accountable for the quality of their appraisals.
9) The quality assurance and appeal procedures must prevent the undue influence of a single individual on appraisal judgments and the personnel decisions that may flow from them.
10) The program must provide an opportunity for the employee to discuss the appraisal and introduce comments or new data into the record and a channel of recourse for those who feel a particular appraisal is unfair.

SYSTEM DESIGN

There are an infinite number of design possibilities for the performance appraisal system. The must commonly used methods to assess employee performance are the use of the narrative and the rating.

[14]A narrative is a written statement describing the performance and is, of course, directly related to the job. The narrative can be very effectively utilized to document critical incidents, either positive or negative, and is also helpful for work planning. Many companies tie the company goals and such things as management by objectives into the narrative. Often the evaluation will say such things as "goals have been met for this period". Narratives have the disadvantage that comparison between employees or comparison over a long time is often difficult to explain in a narrative format.

[15]The use of ratings is another method used to evaluate employees. It has the advantage that it is easier to administer and also quite effective in defending the organization against possible charges of discrimination in compensation and promotion. One problem, however, is that numerical ratings, which are commonly used, suggest a precision which is not really evident in the subjective evaluation of an employees performance. This subjectivity certainly removes the precision and makes it very difficult to explain the differences of numerical values as they relate to overall job performance.

[16] In a research project conducted in California, 18 national and international companies with headquarters in California were interviewed to learn the types of performance evaluation systems that they employed. In 78 percent (14) of the companies a combination of narrative and rating formats was used. Three companies (17 percent) used only the narrative format and one company used rating alone as the sole factor for assessing employee performance.

[17] The trend to use multiple appraisal techniques (i.e. narrative and rating scale combinations) is confirmed by research comparing performance appraisal systems in 1977 as compared with 1979. In 1977, 58 percent of the companies interviewed used multiple appraisal techniques. In 1979 that number had increased to 78 percent.

By combining formats the advantages of both are maintained and the disadvantages are minimized.

[18] Another trend confirmed by research was that 83 percent of the companies surveyed in 1979 had different performance appraisal systems for exempt and non-exempt employees.

Because of the diversity of methods and formats used to evaluate performance, I will only list the more popular methods and briefly describe them.

FORMAT

I. Checklist - 15-50 statements describing important employment criteria are listed such as, "maintains records systematically and orderly". The interviewer checks the statements which describe the employee. The number of checks are then tabulated.

  A. Simple checklist - The individual criteria are considered of equal value. Tabulation amounts to adding all the check marks for the raw score.
  B. Weighed Checklist - The factors noted that are possessed by the employee are assigned different degrees of importance. As a result, the factors are weighed based on the importance to the job. For example, "does excellent work" might be judged more important than "works well with new employees".
  C. Forced-Choice Checklist - Usually 2 to 5 statements are given about a particular factor of employment. The supervisor must select the statement which comes the closest to describing the specific characteristic.

II. Rating Scale - The specific element of performance is fitted into a scale of either numerical or descriptive statements which best apply. This method is considerably easier to use than the narrative-only method.

  A. Numerical Anchors - Scales such as 0 to 10 are listed on a number line. The supervisor places the employee anywhere on the line. In this way, minute levels of improvement or decline can be indicated. For example, the employee might improve his score in a particular aspect of the evaluation from 6.7 to 6.9.

B. Adjectival Anchors - The scale uses adjectives to describe the endpoints of performance. The low end of performance could be deemed unacceptable and the upper end could be termed excellent. The supervisor places the employee along the scale at any point.

C. Numerical Intervals - This method is similar to numerical anchors except intervals such as 0, 1, 2, 3, etc. are specified and the performance must be assigned to a whole value.

D. Adjectival Intervals - In this method typically five values are given such as, unacceptable, marginally acceptable, acceptable, good and superior. One of the adjectives is selected as the most representative.

E. Behavioral-Anchored Rating Scale (BARS) - Although this method is somewhat similar to adjectival intervals, it merits comment. This method combines the narrative-type evaluation and rating scale methods by assigning point values to phrases describing performance. For example: when assessing training 0 on the scale might be "ignores agreed upon training procedures" and 130 might be "influences others in achieving a high level of crew training and assists with training in other departments".

INTERVIEW

The personal interview is the medium by which the performance evaluation is conducted. There are a number of ways to proceed with the interview.

[19]The meeting should be held in a private office with no interruptions. Because of the tendency for employees to be nervous when called into the office, it is advisable to schedule the interview a few days before the meeting. The employee should be told the purpose of the meeting and advised to be prepared to present any questions he or she might have about their job. This will eliminate a great deal of tension and will inform the employee that you are interested in fielding their questions and concerns.

[20]The effective interview is conducted in 4 phases:
1) Warm-up: In order to further relax the employee, it is important to break-the-ice". The idea is to make the employee an active participant in the evaluation procedure. It is easy to find a subject to talk about with the employee. This relaxing talk helps to move on to the next phase.
2) Body: In this portion of the interview your appraisal of the employee's work is analyzed and discussed. I suggest following a simple format such as top to bottom, and front to back. In this way the employee will not be confused by skipping around. This section of the interview should be the longest because it is the heart of the evaluation. In this phase the good performance is praised and the poor performance is addressed in terms of what can be done to improve. A common fallacy is that it is not important to set goals for average or better than average employees. It is this employee that can be motivated to the greatest degree. Goals should be set for all employees. A good employee can become a great employee with the proper skills, motivation and direction.

3) Empathy: In this phase of the interview the supervisor should listen more than speak. It is important to allow the employee to express his/her opinions and thoughts. Do not, however, allow this part of the interview to extend into a lengthy session. Try to curtail this discussion and proceed through the interview.
4) Penetrating Questions: This section of the interview allows the supervisor to learn about particular problems and difficulties by posing questions to the employee.
5) Summary - Although Richard Henderson does not include this step in the process of performance appraisal interview, I believe it is vital to the effectiveness of the procedure.

The interview should end by reviewing and summarizing the goals agreed upon for the next period and future expectations. It is in this phase that employment potential can be discussed. This is also the phase in which you hope to turn around a poor evaluation by leaving the marginal employee with a sense of goals and hopes to improve their rating in the next period.

[21] The following ten helpful hints should be followed when conducting the performance evaluation interview.
1) Plan the review. Be prepared. Have all necessary information available for possible use in the interview. This would include the personnel file, previous evaluation forms, and attendance records.
2) Pinpoint key information. It is important to understand that the best way to achieve success is to work on one aspect at a time. If an employee has five critical faults, you should isolate the worst and concentrate on it. The other faults should be mentioned, but the concentration should be directed toward one item to achieve success.
3) Minimize wasted time. As I previously mentioned the greatest potential for wasting time is in the empathy phase of the interview. Get the interview back on the right track as soon as possible.
4) Pause. Allow the employee to become active in the discussion by giving him/her a chance to interject comments into your presentation.
5) Listen and Observe. When the employee responds to your presentation listen and be aware of non-verbal cues that indicate the actual feelings.
6) Orient and clarify. Keep the interview simple. Clarify any ambigious statements and proceed.
7) Keep an open mind. This is also quite important. During the empathy phase of the interview you are quite likely to hear that your best employee is causing this employee some difficulty. Listen, openly and evaluate all the facts.
8) Summarize. As I previously noted, this is a very critical phase of the evaluation. Your closing comments are what the employee leaves with. Take the opportunity to make it a positive thought on his/her mind.
9) Follow-up. If the plans and expectations set for the next review period are forgotten about, the employee will quickly lose faith in the evaluation system.
10) Avoid Bloodbaths. Do not ever betray a confidence of an employee. This is easy to do by agreeing with the employee when they are criticizing another employee. It is not worth risking your reputation to agree with an employee's criticisms.

PROBLEMS - INTERVIEWERS

[22]"Probably the most damaging aspect of current performance appraisal programs is the use of subjective judgments rendered by a single untrained appraiser."

This statement is unfortunately quite accurate. There are a number of mistakes made by interviewers which are made mostly because of a lack of training and an unawareness of tendencies which are difficult to avoid when evaluating employees.

They are:[23]
"halo effect" - rating the appraisee excellent in one quality and then allowing that factor to influence the rating in other qualities higher than are actually deserved.
"horn effect" - The opposite of the halo effect. In this problem the low rating in one area causes the interviewer to reduce all scores lower than are deserved.
"central tendency" - The tendency to centralize the ratings based on the assumption that all employees will fit into the typical bell-curve distribution is erroneous. The error is in assuming there are as many unacceptable employees as excellent employees. Obviously, the unacceptable employee is subject to termination and therefore their number is reduced. The tendency to form curve which is not centered on the midpoint is called nonparametric distribution. [24]
"strict rater" - overly harsh ratings on the low end of the scale.
"lenient rater" - very lenient ratings given on the upper end of the scale. This tendency is more observable than harsh rating. The reasons are that often the supervisor thinks that if the employees are rated high it appears that they deserve the rating based on the supervisors excellent skills. Also, the supervisor in assuming that the performance evaluation is tied somehow to merit pay tends to try to gain merit pay for all of this employees. This tends to equalize the ratings and the merit pay which might result. The effect is to remove the merit recognition principle.
"latest behavior" - this describes the tendency to rate the employee either good or bad based on a recent happening.
"initial impression" - this describes the tendency to base the entire evaluation process on your first impression.
"spillover effect" - this is the tendency to base present evaluations on historic ratings unjustly. The effect can either be positive or negative.

The errors made by supervisors are somewhat understandable although certainly not excusable. The errors come as a result of insufficient training, primarily.

[25]The supervisors that are not totally dedicated to the proposition of performance evaluations often share these common convictions:
1) they often believe that all employees think they are average or better than average and if they rate them below average they will get mad at them and this will lead to reduced cooperation and overall effectiveness.
2) they often believe that the evaluation takes a lot of time with little improvement to show for this investment.

3) they also believe that identifying individual differences between employees will cause intragroup jealousy, rivalries, and hostilities which will further erode unit performance.

SOLUTIONS - INTERVIEWERS

Although it us unlikely that 100 percent support for performance evaluations will ever arise, a number of factors can be given to improve the accuracy.

[26]1) Gain more familiarity with the behaviors to be appraised.
2) Document behaviors through the evaluation period to improve recall.
3) Maintain a checklist to obtain and review job performance and other related information.
4) Be aware of personal biases as described on pages 12 and 13 and take actions to minimize their effects.
5) Maintain a higher level of management to review performance appraisals in order to oversee the quality of the appraisals.
6) Compare rating scores across all supervision and across all members of the unit to insure reliability.
7) The appraiser should focus on performance-related behavior over which the appraisee has greatese control.
8) The appraiser ratings should be tied to the performance of the unit in general.

TRENDS: SELF-APPRAISAL

There has been a tendency to move more toward self-appraisal as a way to make the employee take an active role in the evaluation interview. This method can be quite effective when used in the right situation.

[27]In a three year research study at the USAF Academy it was discovered that if the criteria and method of evaluation were consistent, the cadets could predict their ratings with a high degree of success.

The research further determined that, "a consistently applied policy, supported by a well-designed training program, helps subordinates not only to understand how performance is appraised but also provides intuitive cues for assessing one's performance in an accurate way."

SUMMATION

The performance appraisal system is an effective means by which the employer can motivate employees. Although I have not totally specified the entire implementation process I have sketched the critical factors.

[28]The Personnel Officer is responsible for policy making and providing advice. This fact has been confirmed through research. In one study, 78 percent of Personnel Officers described their primary function related to performance evaluation as advisory. It is a common misconception that the evaluation system is established to benefit Personnel. It is not. The benefits to be gained are at the departmental level through a dedicated effort to the principles of performance evaluation.

Performance review of a very useful tool for the Physical Plant Administrator. Evaluation and motivation can be accomplished effectively through an effective performance appraisal system. If you desire some assistance in the implementation of a system, do not hesitate to call me at (304) 293-2731.

FOOTNOTES

[1] Richard Henderson, *Performance Appraisal* (New York, New York) pp 7.

[2] Melvin E. Schake, "The Performance Evaluation as Motivating Tool", *Supervisory Management*, Volume 23, Number 7 (July 1979), 33.

[3] "Performance Appraisal", *Supervisory Management*, Volume 23, Number 10 (October 1978), 12-16.

[4] Donald E. Klingner, *Public Personnel Management; Contents and Strategies* (Englewood, California: Prentice-Hall, Inc., 1980), pp. 227-8.

[5] Marion J. Kelley, *What To Do About Performance Appraisal* (New York: AMACOM, 1975) page 8.

[6] Michael C. Gallagher, "More Bias in Performance Evaluation", *Personnel*, Volume 55, (July-August 1978), pp. 24-34.

[7] Schake, op. cit., pp. 37.

[8] Ibid.

[9] "Performance Appraisal", page 12-16.

[10] Henderson, op. cit., pp. 218.

[11] Klinger, op. cit., pp. 359.

[12] Henderson, op. cit., pp. 21.

[13] Daniel Lupton, "The Ten Commandments of Valid Performance Appraisal", *Personnel*, Volume 56, (September-October 1979), pp. 45-8.

[14] Ibid.

[15] Kenneth S. Teel, "Performance Appraisal: Current Trends, Persistent Progress", *Personnel Journal* Volume 59, Number 4 (April 1980), pp. 296-301.

[16] Ibid.

[17] Ibid.

[18] Ibid.

[19] Henderson, op. cit., pp. 119.

[20] Ibid.

[21] Ibid. pp. 131-2.

[22] Lupton, op. cit., pp. 45-8.

[23] Henderson, op. cit., pp. 104-5

[24] Ibid, pp. 17.

[25] Henderson, op. cit., pp. 19.

[26] Ibid, pp. 178-80.

[27] William D. Wilsted and Robert L. Taylor, "Identifying Criteria for Performance Appraisal Decisions", Journal of Management Studies Volume 15 (October 1978) pp. 255-58.

[28] Teel, op. cit., pp. 299.

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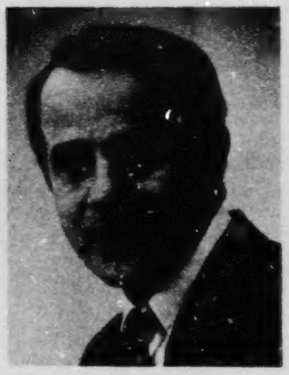

Phased Approach to a Central Chiller Facility

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Abstract

This paper describes the procedure used in arriving at a phased approach to a central chilled water facility for the State of Michigan Capitol Complex in Lansing, Michigan.

Included is a discussion of the owner's goals, basic elements of the study and implementation of the results of the study, including the initial phase, the second phase and planned future phases. In addition, there is a discussion of general design parameters that should be considered in planning such a facility.

Introduction

The impetus for this project was a knowledgeable owner who recognized the potential for a true long range solution to his air conditioning requirements that promised substantial cost savings and improved reliability.

The project was initiated in 1974 when we were commissioned to perform a study to determine the various alternatives to providing air conditioning for the capitol complex.

The justification for the study lay in the fact that one of the existing chillers was failing and was in need of replacement. It was felt that, since the replacement cost was substantial, this money might better be committed to a comprehensive, long range solution to the air conditioning requirements of the complex.

Existing Conditions

Figure 1 illustrates the conditions existing at the time of the study.

The area of immediate concern was the four block complex which contained the Mason Building, Treasury Building, Highway Building and Law Building.

Each building had a single low pressure steam absorption chiller. The unit in the Mason Building is the one that was failing. With this arrangement there was no stand-by capability for any of the buildings.

Planned Expansion

Figure 2 illustrates the ultimate planned expansion of the capitol complex and shows that the planned future development is extensive in relation to the complex existing at that time.

With this in mind, along with the fact that the chiller in the Mason Building was failing, it was concluded that this was the appropriate time to evaluate the long range alternatives for air conditioning of the capitol complex.

Goals

The owner's basic goal was to implement a long range solution to the air conditioning requirements of the capitol complex that considered:

1. Total life-cycle cost.

2. Stand-by capability.

3. Simplicity of operation and maintenance.

4. Flexibility.

5. Expandability

6. Ability to implement on a phased basis with emphasis on completing the initial phase within very tight budget constraints.

Study

The study considered 84 combinations of variables, including three distribution schemes, four types of refrigeration equipment and seven stages of development of the system as indicated below:

Stages of development

1. Highway, Law, Treasury and Mason Buildings (All existing).

2. Same as "1" plus existing Cass Building and new Office Building #5. Complete in July, 1978.

3. Same as "2" plus new Office Building #1. Complete in July, 1980.

4. Same as "3" plus the new Capitol Building. Complete in July 1985.

5. Same as "4" plus one third of the remainder of the ultimate development (New Office Buildings No. 2 and 3). Complete in July, 1990.

6. Same as "5" plus an additional one third of the ultimate development (New Office Buildings No. 4 and 6). Complete in July, 1995.

7. Same as "6" plus the final one third of the ultimate development. (Existing Civic Center and the Existing Capitol Building). Complete in July, 2000.

Refrigeration equipment

1. Electric motor driven centrifugal.
2. Steam turbine driven centrifugal.
3. Low pressure absorption.
4. High pressure absorption (two stage).

Distribution

1. Central chilled water plant.
2. Decentralized loop with "satellite" chillers.
3. Individual chiller plants for each building.

The study was done on a life cycle, or total annual owning and operating cost basis considering the following parameters:

1. Initial cost.
2. Energy cost.
3. Replacement cost.
4. Cost for operating personnel.
5. Maintenance cost.
6. Interest and inflation.
7. 50 year period - 1975 through 2024.

The study also provided raw source energy consumption, based on factors obtained from the Board of Water and Light which supplies both electricity and district steam to the capitol complex. The factors used were .77 for steam and .31 for electricity (total useful energy at the point of use divided by energy consumed by the Board of Water and Light to generate that energy).

Results of Study

Financial: For each type of distribution scheme, electric motor driven centrifugal chillers provide the lowest life cycle cost compared to low pressure absorption, high pressure absorption and steam turbine driven centrifugal chillers. This is illustrated in Summary Table 1.

A comparison of the various types of distribution schemes, all using electric centrifugal chillers indicates that the life cycle costs for the Central and Loop Schemes are approximately equal and the Individual Scheme has a life cycle cost that is approximately $245,000 per year greater.

Energy: For each type of distribution scheme, the use of electric motor driven centrifugal chillers results in the lowest raw source energy consumption compared to the other types of chillers considered.

A comparison of the various types of distribution schemes, all using electric centrifugal chillers indicates that the Central Scheme has the lowest raw source energy consumption, the loop scheme the next lowest, consuming approximately 1.63 trillion BTU additional and the Individual Scheme has the highest energy consumption at approximatel6 4.06 trillion BTU more than the Central Scheme. This is illustrated by Summary Table 2.

Conclusions: Electric centrifugal chillers provide the lowest life cycle cost and consume the least raw source energy compared to the other types of chillers considered in this study regardless of the type of distribution scheme.

Based on electric centrifugal chillers, the life cycle costs of the Central and Loop Schemes are approximately equal. The raw source energy consumption is lower for the Central Scheme compared to the Loop Scheme.

Since there is no cost benefit to the Loop Scheme compared to the Central Scheme, the energy consumption is higher and there are numerous "intangible" factors that favor a central system, the Loop Scheme can be eliminated.

Some of the intangible factors favoring a central system include better stand-by capabilities, simplified system operation and maintenance, more freedom of design in the buildings and better space utilization in the buildings.

This brings us to a comparison of the Central Scheme and the Individual Scheme, with electric centrifugal chillers for both.

The life cycle cost savings for the Central Scheme compared to the Individual Scheme will be approximately $245,000 per year.

The raw source energy savings over the 50 year period will be 4.06 trillion BTU for the Central Scheme compared to the Individual Scheme. This is enough energy to heat 400 average size homes for 50 years.

The intangible factors mentioned above also apply here to an even greater extent.

Recommendations: Based on cost and energy considerations, the central scheme, utilizing electric centrifugal chillers, is the recommended method of providing air conditioning for this project.

SUMMARY TABLE 1

LIFE CYCLE (TOTAL ANNUAL OWNING AND OPERATING) COST SUMMARY

Scheme	Low Press. Absorption ($)	High Press. Absorption ($)	Stm Turbine Centrifugal ($)	Electric Centrifugal ($)
Central	5,212,436	4,904,190	4,912,660	4,610,175
Loop	5,056,986	4,858,609	4,876,931	4,607,194
Individual	5,261,522	5,082,360	5,095,923	4,855,360

SUMMARY TABLE 2

TOTAL RAW SOURCE ENERGY CONSUMPTION SUMMARY

Scheme	Low Press. Absorption (Million BTU)	High Press. Absorption (Million BTU)	Stm Turbine Centrifugal (Million BTU)	Electric Centrifugal (Million BTU)
Central	40,767,857	35,736,472	36,158,305	30,753,834
Loop	40,045,192	36,128,804	36,484,305	32,382,741
Individual	41,705,652	38,235,566	38,479,103	34,812,987

(Total Consumption for the 50 year period 1975 through 2024)

Implementation

Priorities: Priority had to be given to providing a dependable air conditioning supply for the Mason Building, whose chiller was failing.

Total funds available were limited to approximately $1,000,000. This was substantially less than would be required to construct the first stage of a central chilled water facility and the associated distribution system.

However, it was determined that the total installed refrigeration capacity in the Treasury, Highway and Law Buildings was adequate to cool all buildings in the four block area, including the Mason Building, when taken as a whole and considering load diversity among the buildings.

It was further determined that within the constraints of the available funds, all of these buildings could be interconnected by a piping loop to allow air conditioning of all buildings, while operating only the number of chillers required by the total load.

Therefore, the decision was made to implement the loop arrangeent with the stipulation that it be designed such that it could be incorporated as part of the planned future central chilled water distribution system. This became Phase I of the project.

Arrangement: Figure 3 shows the piping arrangement that was used. Figure 4 illustrates the operation in the series loop mode which would be in effect until the central chilled water facility was implemented at a later date.

Figure 5 illustrates the operation in the central system mode with all buildings connected in parallel, in lieu of the series arrangement of Figure 4.

Physical considerations: The entire four block area includes a two level underground parking structure. Evaluation of the alternatives led us to conclude that the distribution piping, which ranged up to 18" in size, would have to be located within the parking structure. A fortunate development occurred that made this a relatively simple task, compared to what it might have been. A mail conveyor that serviced the entire four block area had been taken out of service and, upon investigation, it was found that by removing the mail conveyor and installing the piping in its place, we could gain access to all required areas, including the penthouse mechancial rooms. With the owner's approval, we proceeded on this basis and, with the exception of a number of very tight areas, found that the installation of the entire piping distribution system was completed with little difficulty.

Operational considerations: Since the parking structure is unheated, provisions for freeze protection had to be made. The basic provisions included a small set of pumps to maintain circulation and a heat exchanger to heat the loop from the condensate after metering and prior to discharging to the sewer system (condensate is not returned to the utility).

Large drain valves, suitable for attaching fire hoses were provided at all low points for draining the system in an emergency.

Key points were also monitored and alarmed from the owner's central monitoring and control system.

Subsequently, the owner has added the computer centers contained within the buildings in the four block area to the system. This results in the addition of more than enough heat to the system to prevent freeze-up. The computer centers will be discussed in more detail later in this paper.

With the loop arrangement, the loads are connected in series, resulting in varying supply chilled water temperatures depending on the location in the loop, which chillers are operating and the magnitude of the other loads that are connected to the loop. This is illustrated by Figure 6.

Because of this, there may be times when the total loads do not exceed the capacity of a single chiller, but two chillers must be run to provide the required supply chilled water temperature to a load that is remote from the operating chiller. The potential for this condition increases when critical loads, requiring certain limits on chilled water conditions are involved.

With the central system, this problem does not exist since the loads are connected in parallel, resulting in the same chilled water supply temperature to all of the loads. This is illustrated by Figure 7.

For this particular project, this has not proved to be a serious problem because loads have been substantially reduced through implementation of energy conservation measures, and space conditions have been maintained at higher levels than those for which the buildings were designed. The net result is that the equipment is now oversized for the reduced load, allowing for satisfactory operation at significantly higher entering chilled water temperatures.

This condition is probably typical of most buildings designed ten or more years ago.

Another potential operational problem occurs with the loop pumps. On this project there were three 100 horsepower loop pumps. Two were intended to operate, with the third being a stand-by unit.

At very light loads there is a temptation to run the system on one pump, which will satisfy the cooling requirements. The problem is that at these lower flow rates the pump may be operating near or beyond the end of its curve and cavitate. This actually occurred on this project, requiring an expensive rebuilding of the pump. This condition is illustrated by Figure 8.

To prevent this condition, the system should either be run with two pumps or, when running a single pump, a throttling valve on the pump discharge should be partially closed to provide a satisfactory operating condition. This condition is illustrated by Figure 9.

Results of "loop": The loop operation has been highly successful, providing significant cost savings, estimated at more than $100,000 per year by the owner, and stand-by capability for all buildings in the four block area. A single chiller serves all buildings a great deal of the time and there have been no instances where, under peak load conditions, the three operating chillers did not provide adequate capacity.

The project was completed within the constraints of a very tight budget and all physical problems were resolved in a way that did not result in the loss of precious parking spaces or in locating equipment in areas that were inaccessible or created other maintenance difficulties.

Phase II

Phase II involved the first stage of the central chiller plant to accommodate a major new office building.

This project also involved a very tight budget that basically allowed for installing only enough refrigeration capacity to serve the new office building.

Because of this it was not possible to implement the central plant operation wherein the buildings would be served in parallel.

Instead, the combination of the new office building and the central plant were treated as an extension of the loop as illustrated by Figure 10. However, all provisions have been made in pipe sizing and valving to allow for future parallel operation when sufficient central plant capacity has been added.

A 1600 ton electric centrifugal chiller and cooling tower with ceramic tile fill were provided. Provisions have been made for an ultimate expansion to 16,000 tons.

Although occupancy of the new office building was delayed from the summer of 1982 until 1983, the chiller plant was completed and placed in operation in the summer of 1982.

Based on steam costs of $6.00 per 1,000 pounds and electric costs of $.034 per KWH and $5.90 per Kw demand, it is estimated that nearly $90,000 was saved through operation of the electric centrifugal chiller during the summer of 1982. This savings was reduced by approximately $30,000 due to demand penalties during the winter months because the new office building was not occupied.

This demand penalty will not occur in future years when the building is occupied. In order to avoid the demand penalty, electric service for the new office building is provided from the central chiller facility. Provisions have been made to ultimately feed electric service to the entire complex from the central chiller facility.

Also included in the project was a plate and frame heat exchanger to provide a "free cooling" cycle whereby chilled water can be generated without running the chiller when outdoor conditions permit. This generally occurs during the fall, winter and spring months when outdoor wet bulb temperatures are low enough for the cooling tower to produce condenser water temperatures that are approximately 3^{o}F lower than the required chilled water temperature. Figure 11 illustrates this feature.

Implementation of the free cooling cycle allows the computer centers in the complex to be air conditioned for many months of the year with the central chillers and their individual chillers shut down.

Future Phases

Future phases will include expanded capacity in the central plant and a parallel flow arrangement to all buildings.

This will occur as new buildings are added and as the existing steam absorption chillers begin to approach the end of their useful lives.

While it is expected that future chillers will be electric centrifugal, it is possible to utilize other types should a change in relative utility costs make it advantageous to do so.

Design Considerations

General: While the concept for designing a "loop" or central system is very straightforward, there are many potential pitfalls. It is critical that all of the many operating conditions that such a system is subject to be thoroughly thought through. Thoroughness and attention to detail are mandatory for a successful result.

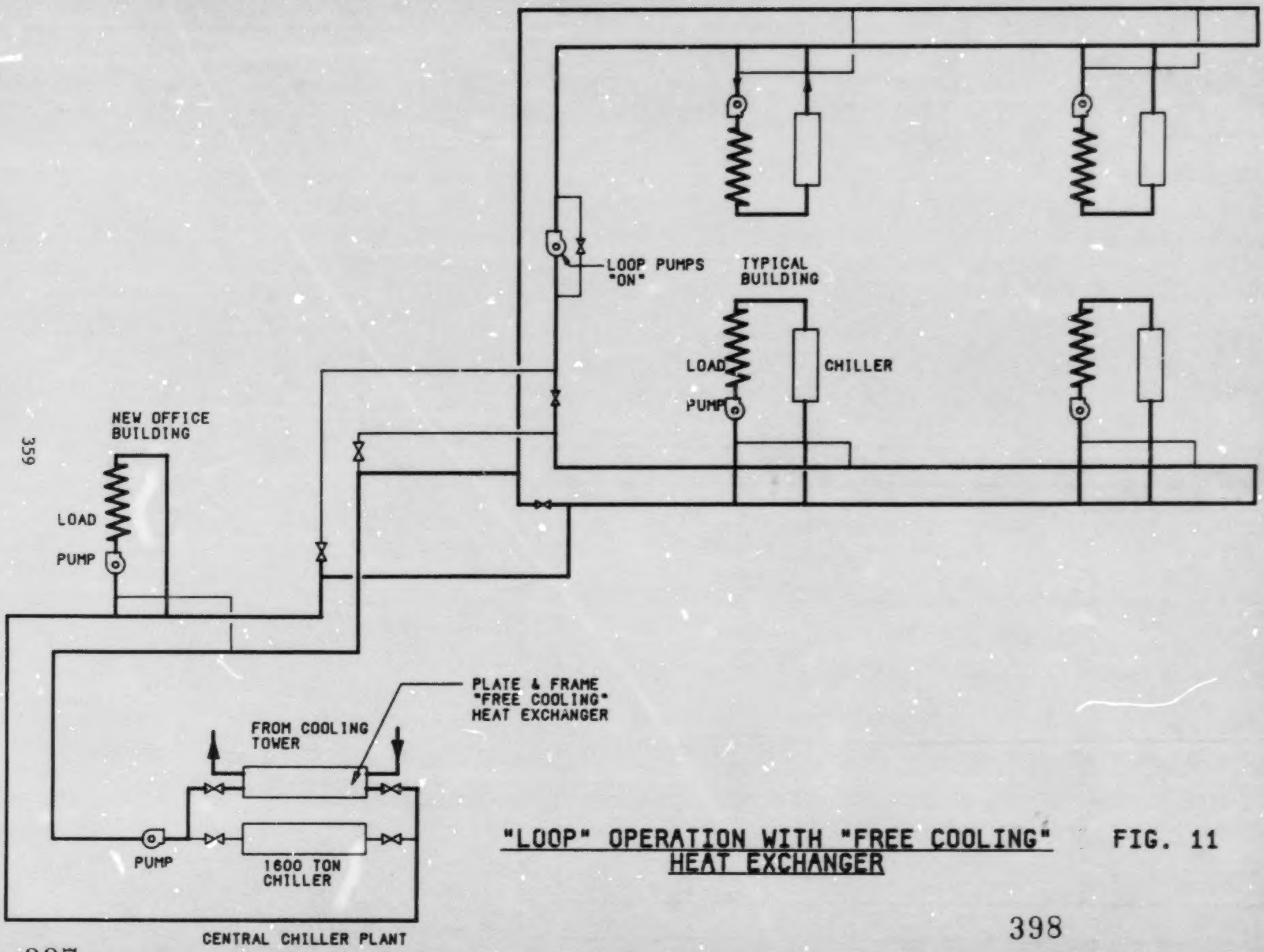
Pumping: For those parts of the system that are variable flow, means must be provided to vary the capacity of the pumps. In some instances staging of multiple pumps might offer a better solution than variable speed pumps.

Control: The pressure differentials across the "bridges" can vary dramatically from full system flow to minimum system flow. The system must be designed to accommodate this condition. In some instances parallel control valves may be required for proper control.

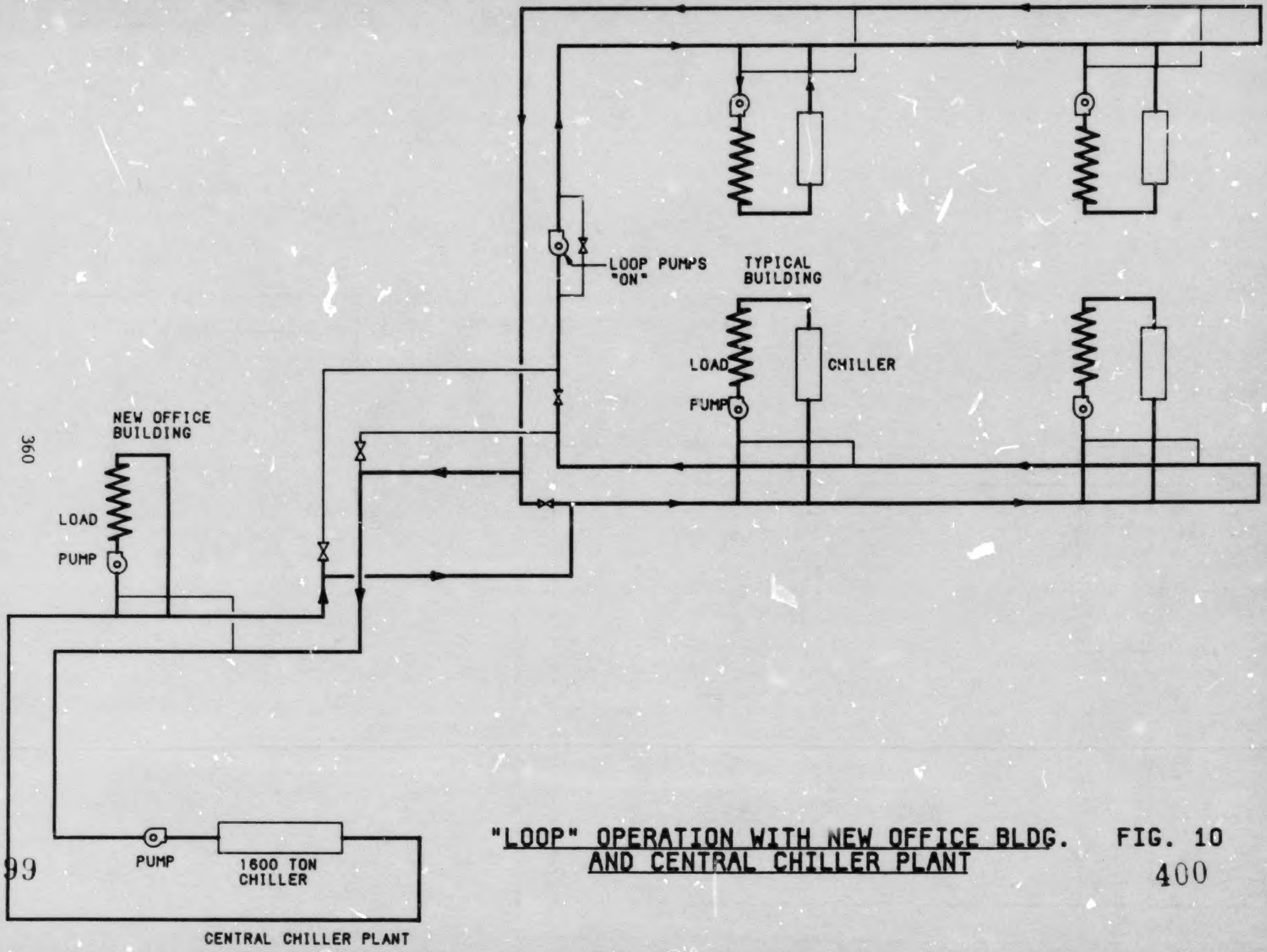
The method of controlling the "bridge" control valves must be carefully considered. It is possible to have a very low water temperature rise across the building loads resulting in a low return water temperature to the chillers. This will require running more chillers than dictated by the load because the low return water temperature will not allow the chillers to develop their full rated tonnage.

Bidding Considerations

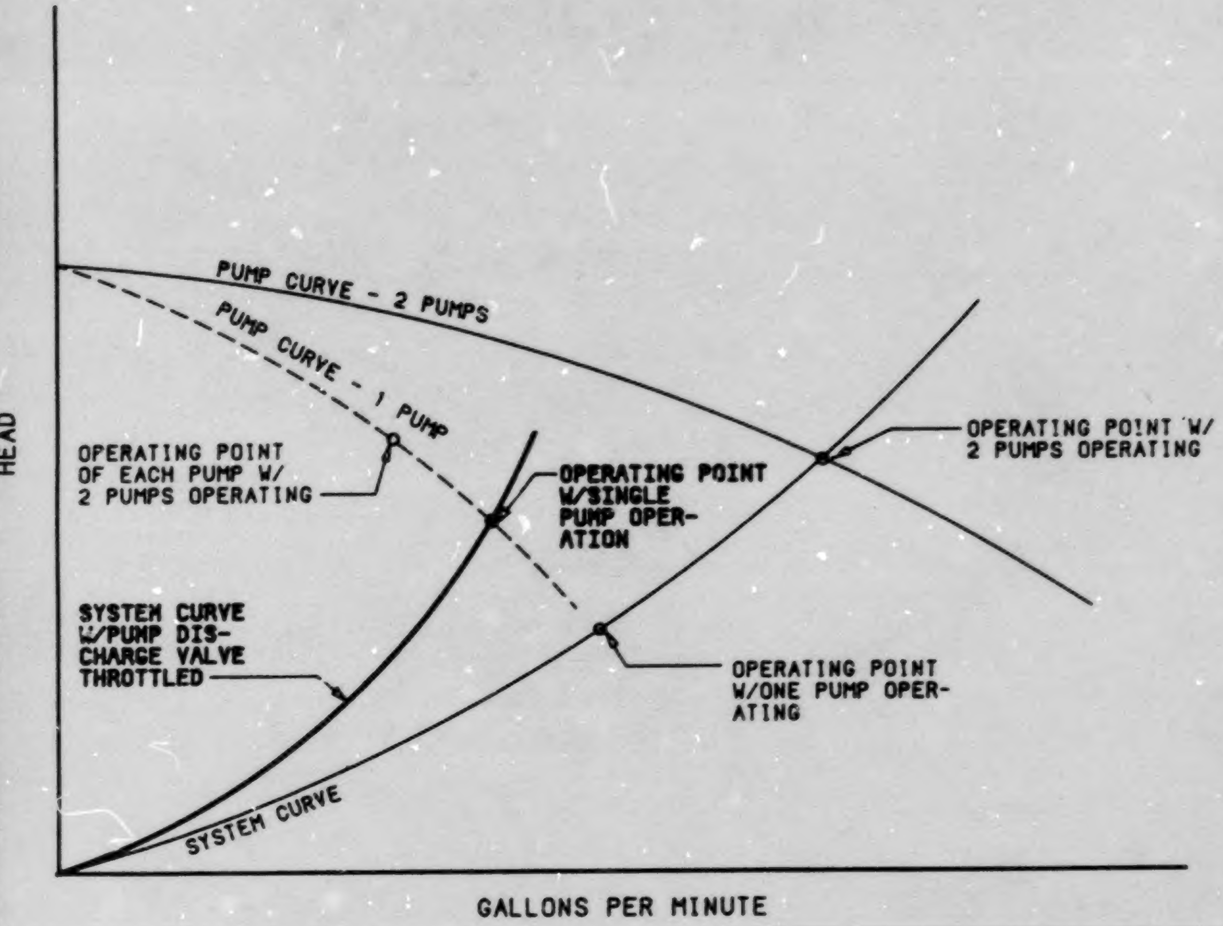
We highly recommend bidding the major components on a life cycle basis. Where we have been able to do this, it has produced outstanding results. In some instances, a modest increase in first cost can produce dramatic savings over the life of the component.


LOOP PUMPS
"ON"
TYPICAL
BUILDING
LOAD
CHILLER
PUMP
NEW OFFICE
BUILDING
LOAD
PUMP
PLATE & FRAME
"FREE COOLING"
HEAT EXCHANGER
FROM COOLING
TOWER
PUMP
1600 TON
CHILLER
CENTRAL CHILLER PLANT

"LOOP" OPERATION WITH "FREE COOLING" HEAT EXCHANGER FIG. 11

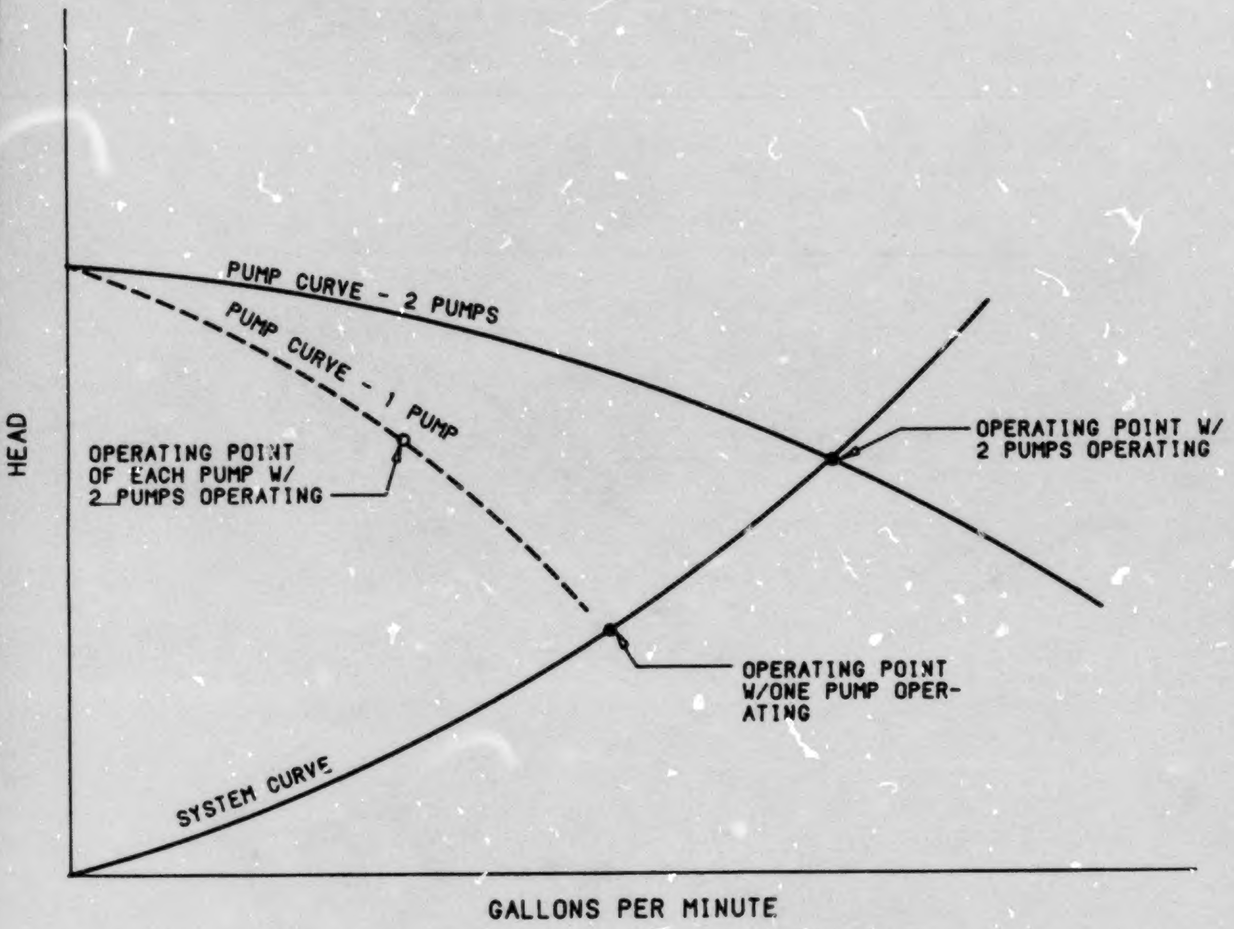

LOOP PUMPS
"ON"
TYPICAL
BUILDING
LOAD
CHILLER
PUMP
NEW OFFICE
BUILDING
LOAD
PUMP
PUMP
1600 TON
CHILLER
CENTRAL CHILLER PLANT

"LOOP" OPERATION WITH NEW OFFICE BLDG.
AND CENTRAL CHILLER PLANT FIG. 10


HEAD
GALLONS PER MINUTE
PUMP CURVE - 2 PUMPS
PUMP CURVE - 1 PUMP
OPERATING POINT OF EACH PUMP W/ 2 PUMPS OPERATING
OPERATING POINT W/SINGLE PUMP OPERATION
OPERATING POINT W/ 2 PUMPS OPERATING
SYSTEM CURVE W/PUMP DISCHARGE VALVE THROTTLED
OPERATING POINT W/ONE PUMP OPERATING
SYSTEM CURVE

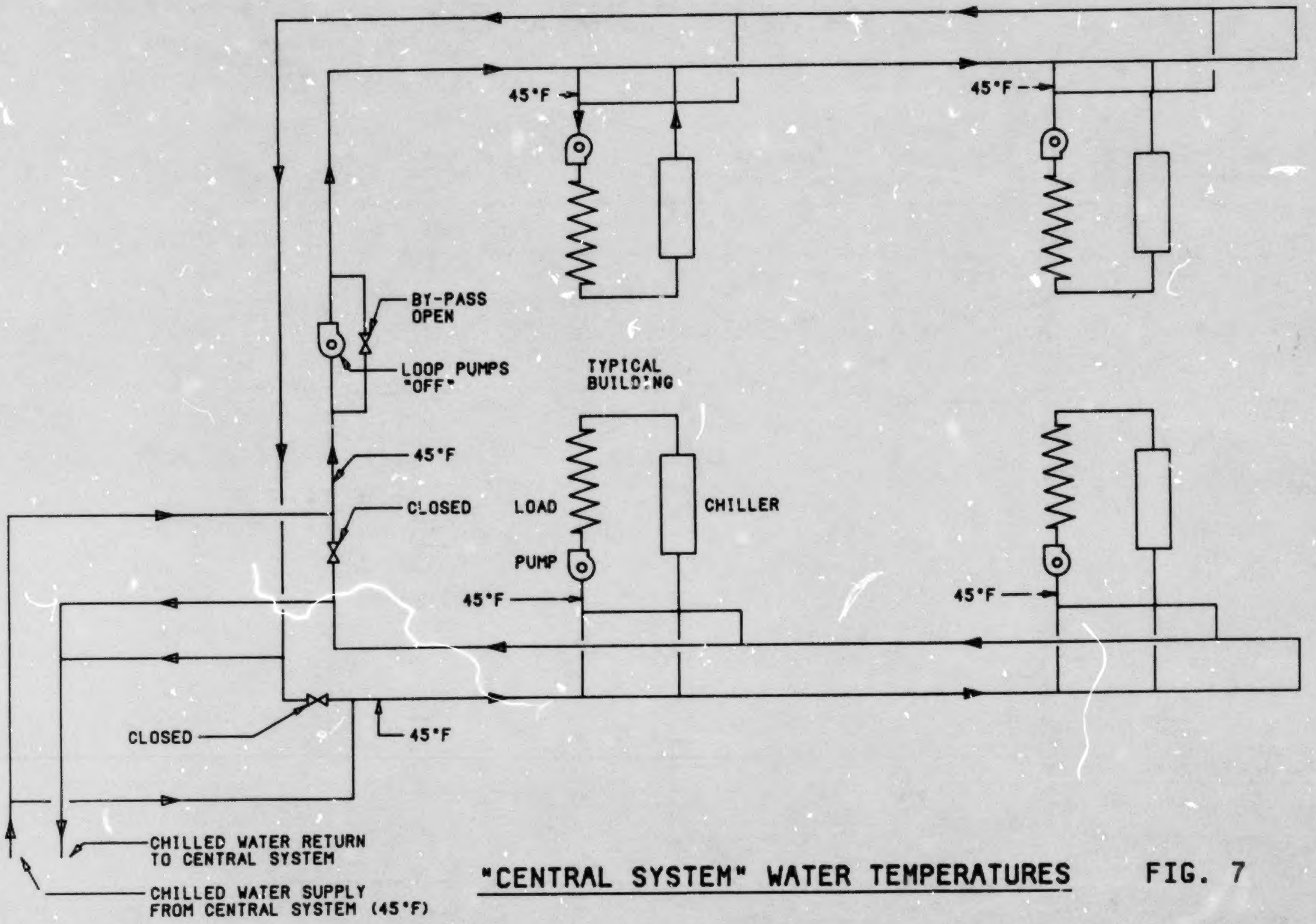
OPERATION WITH ONE PUMP

FIG. 9

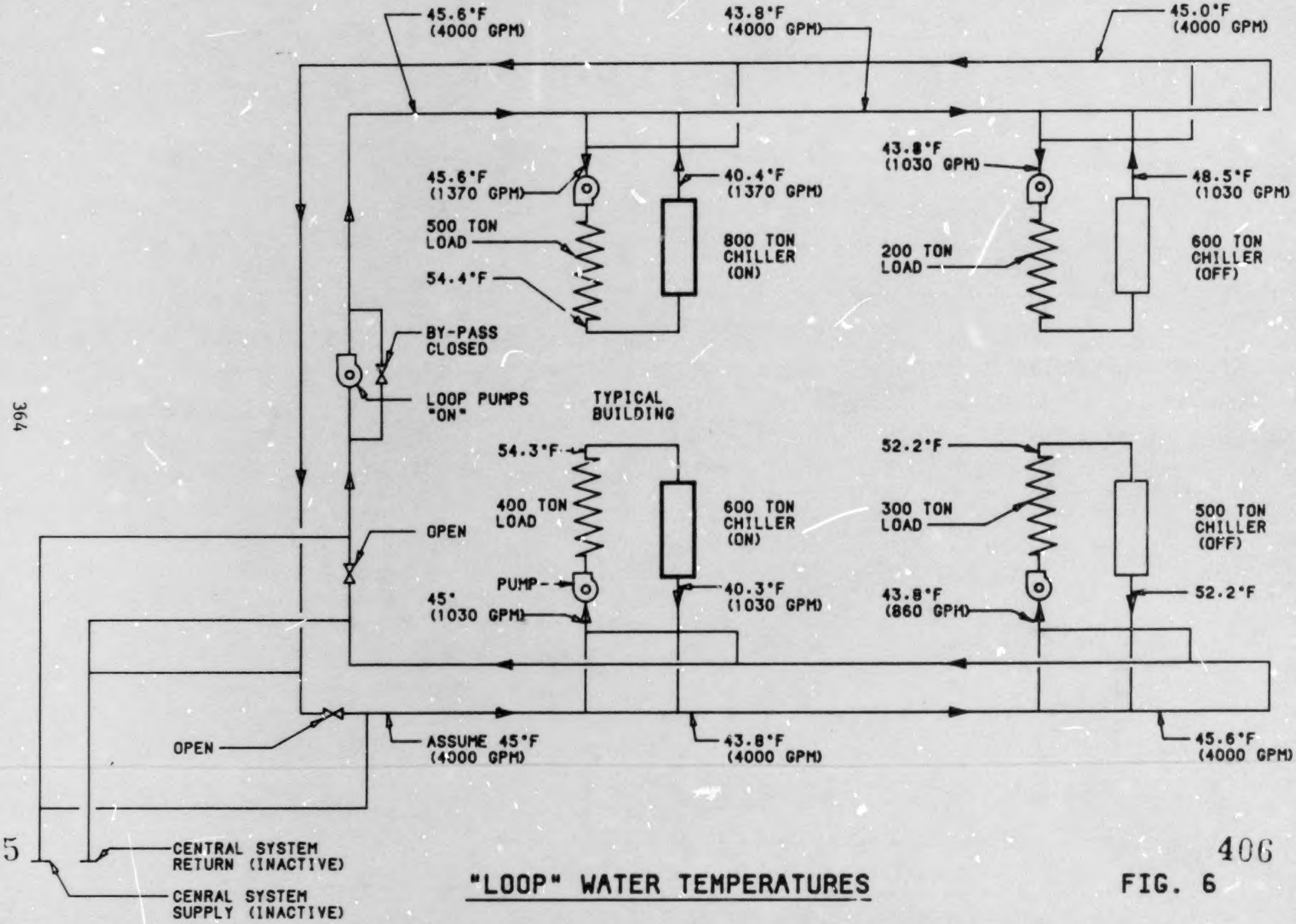


OPERATION WITH TWO PUMPS

FIG. 8

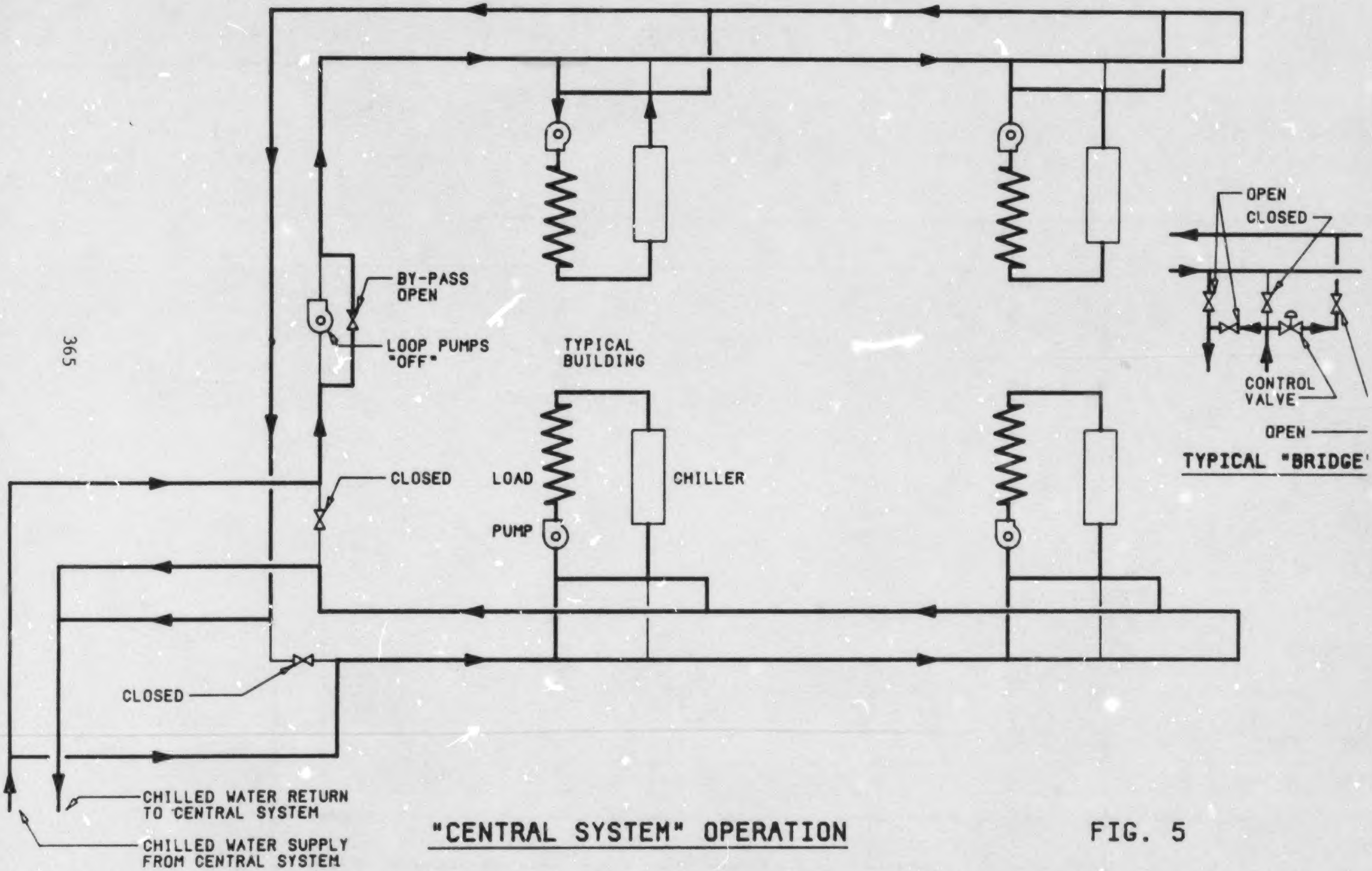

45°F
45°F
BY-PASS OPEN
LOOP PUMPS "OFF"
TYPICAL BUILDING
45°F
CLOSED
LOAD
CHILLER
PUMP
45°F
45°F
CLOSED
45°F
CHILLED WATER RETURN TO CENTRAL SYSTEM
CHILLED WATER SUPPLY FROM CENTRAL SYSTEM (45°F)

"CENTRAL SYSTEM" WATER TEMPERATURES FIG. 7


45.6°F (4000 GPM)
43.8°F (4000 GPM)
45.0°F (4000 GPM)
45.6°F (1370 GPM)
40.4°F (1370 GPM)
500 TON LOAD
800 TON CHILLER (ON)
54.4°F
43.8°F (1030 GPM)
48.5°F (1030 GPM)
200 TON LOAD
600 TON CHILLER (OFF)
BY-PASS CLOSED
LOOP PUMPS "ON"
TYPICAL BUILDING
54.3°F
400 TON LOAD
600 TON CHILLER (ON)
52.2°F
300 TON LOAD
500 TON CHILLER (OFF)
OPEN
PUMP
45° (1030 GPM)
40.3°F (1030 GPM)
43.8°F (860 GPM)
52.2°F
OPEN
ASSUME 45°F (4000 GPM)
43.8°F (4000 GPM)
45.6°F (4000 GPM)
CENTRAL SYSTEM RETURN (INACTIVE)
CENRAL SYSTEM SUPPLY (INACTIVE)

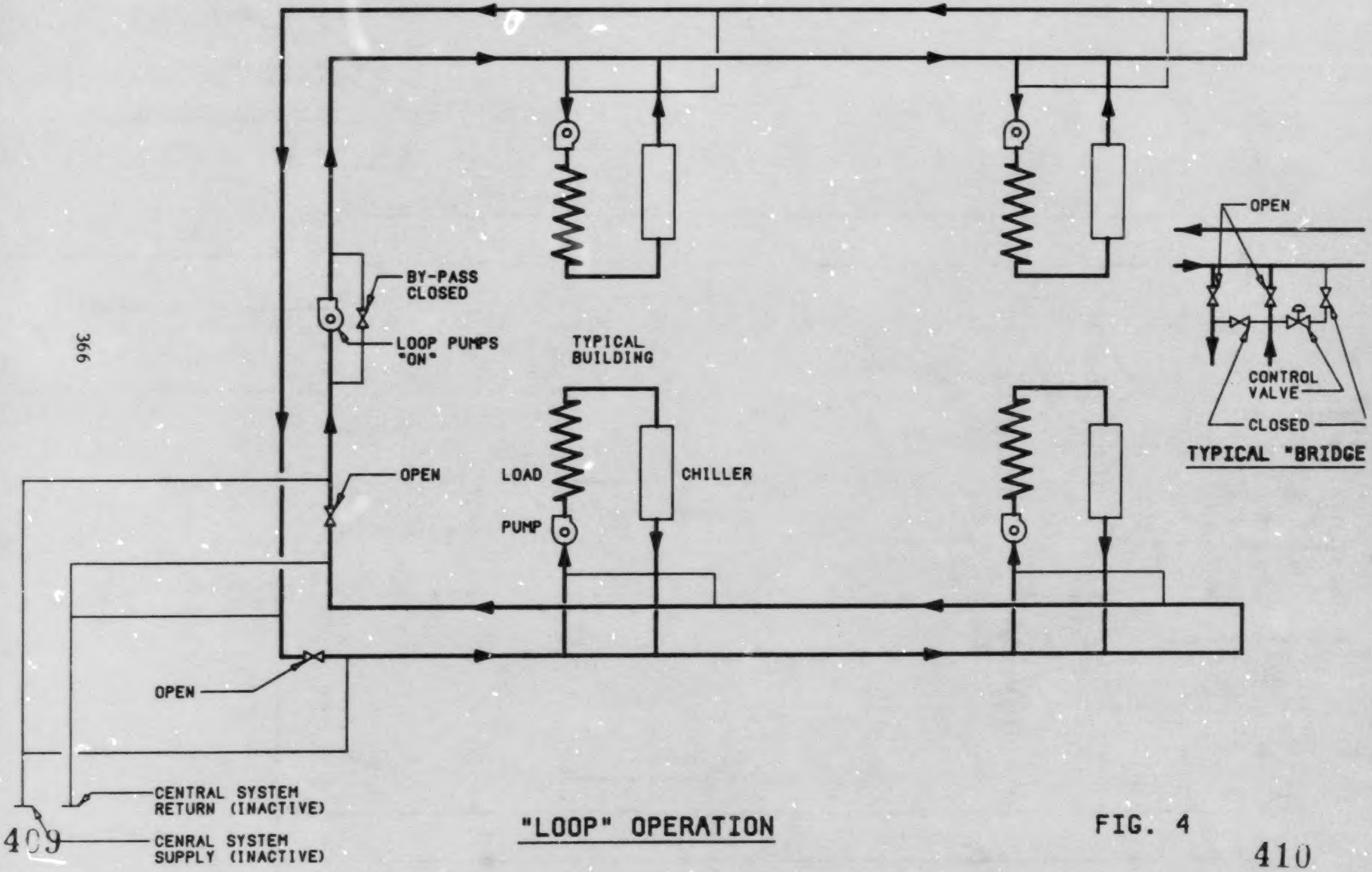
"LOOP" WATER TEMPERATURES

FIG. 6


BY-PASS OPEN
LOOP PUMPS "OFF"
TYPICAL BUILDING
CLOSED
LOAD
CHILLER
PUMP
CLOSED
CHILLED WATER RETURN TO CENTRAL SYSTEM
CHILLED WATER SUPPLY FROM CENTRAL SYSTEM
OPEN
CLOSED
CONTROL VALVE
OPEN
TYPICAL "BRIDGE'

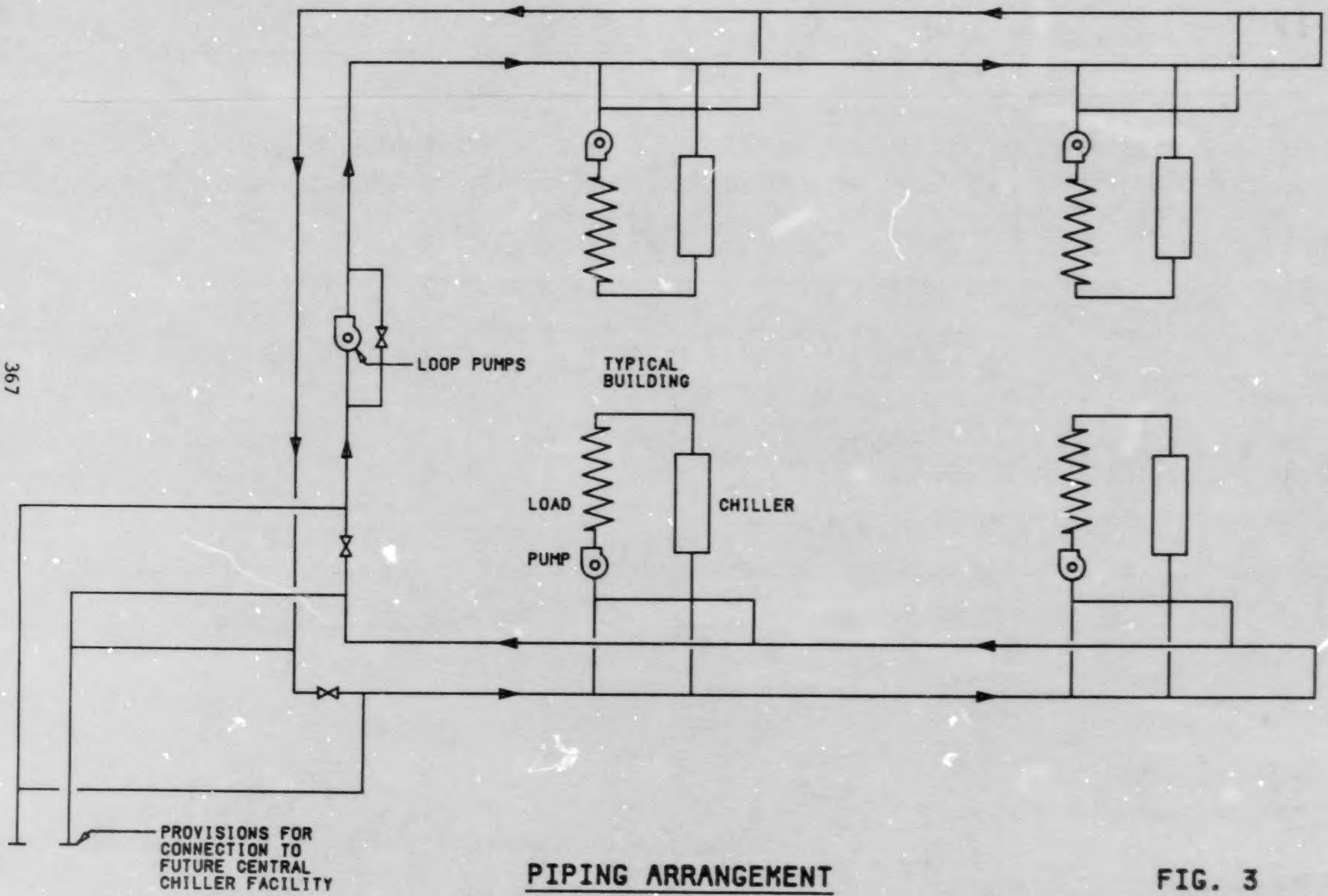
"CENTRAL SYSTEM" OPERATION

FIG. 5


BY-PASS CLOSED
LOOP PUMPS "ON"
TYPICAL BUILDING
OPEN
LOAD
CHILLER
PUMP
OPEN
CENTRAL SYSTEM RETURN (INACTIVE)
CENRAL SYSTEM SUPPLY (INACTIVE)
OPEN
CONTROL VALVE
CLOSED
TYPICAL "BRIDGE

"LOOP" OPERATION

FIG. 4


LOOP PUMPS
TYPICAL BUILDING
LOAD
CHILLER
PUMP
PROVISIONS FOR CONNECTION TO FUTURE CENTRAL CHILLER FACILITY

PIPING ARRANGEMENT

FIG. 3

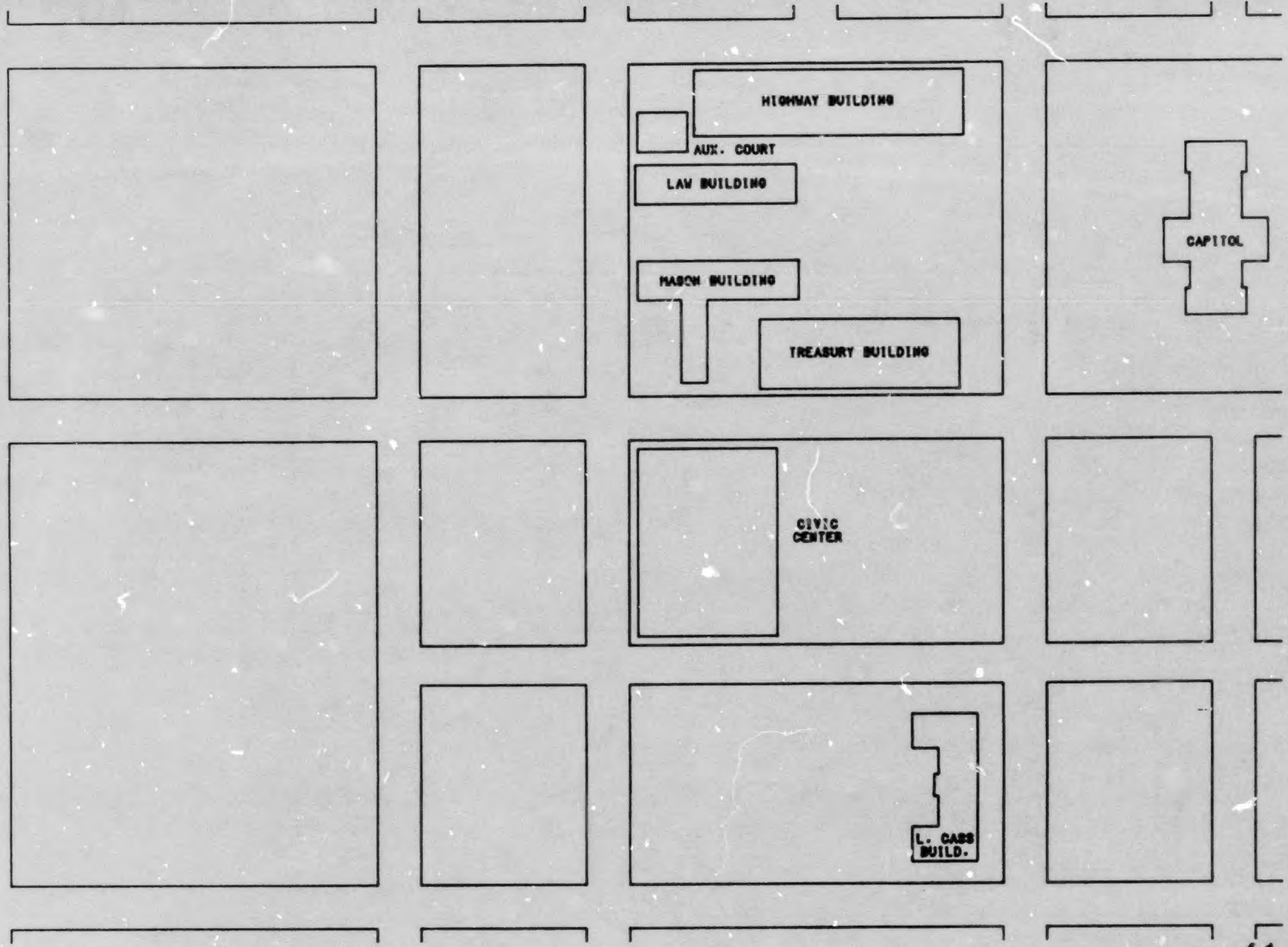

HIGHWAY BUILDING
AUX. COURT
LAW BUILDING
MASON BUILDING
TREASURY BUILDING
CAPITOL
CIVIC CENTER
L. CASS BUILD.

FIG. 2

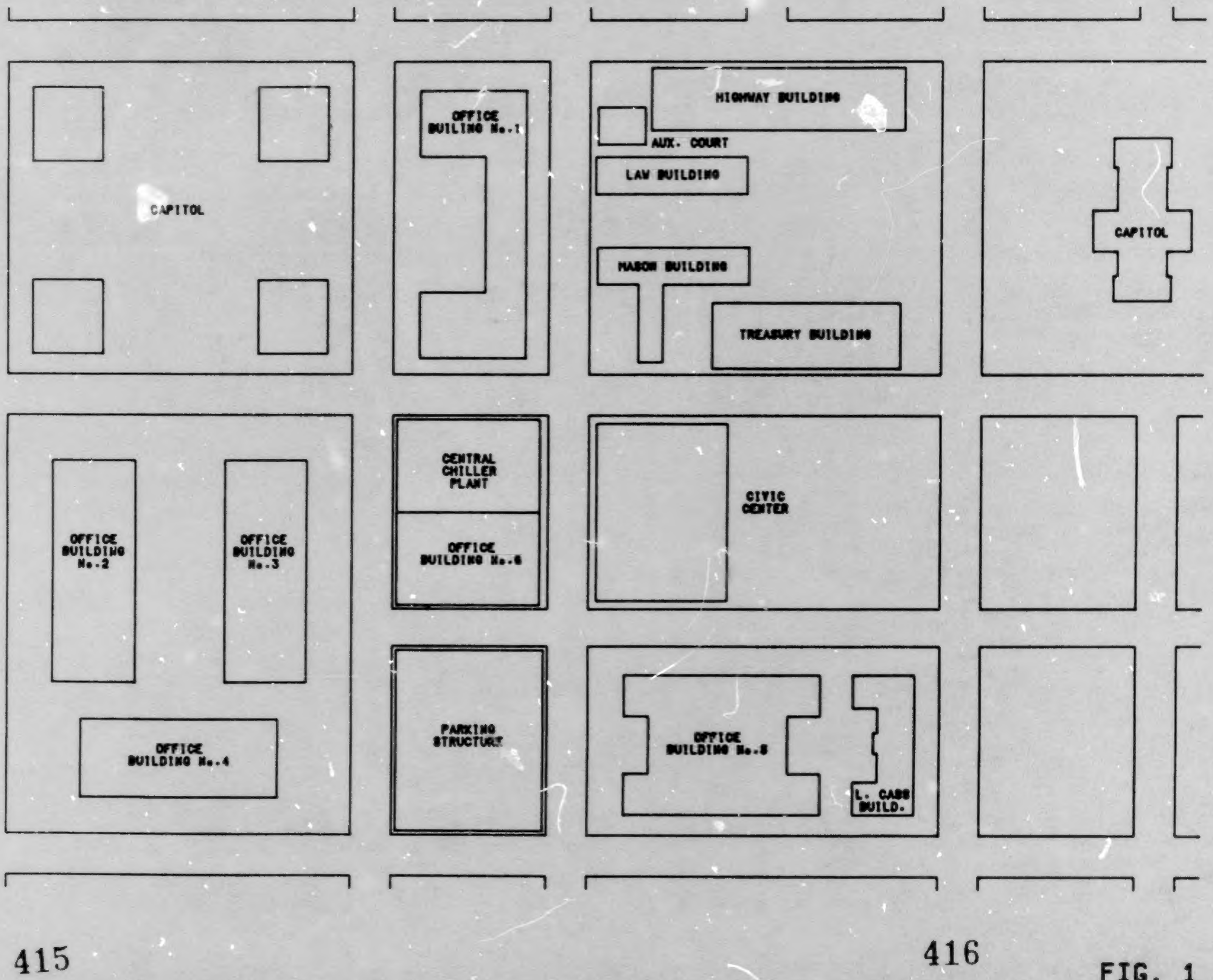
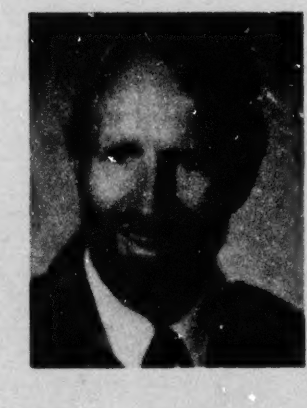

CAPITOL
OFFICE BUILING No.1
HIGHWAY BUILDING
AUX. COURT
LAW BUILDING
MASON BUILDING
TREASURY BUILDING
CAPITOL
OFFICE BUILDING No.2
OFFICE BUILDING No.3
CENTRAL CHILLER PLANT
OFFICE BUILDING No.6
CIVIC CENTER
OFFICE BUILDING No.4
PARKING STRUCTURE
OFFICE BUILDING No.5
L. CASS BUILD.
415
416

FIG. 1



The Six-Two Plan: Custodial Management at the University of Colorado

By John Madsen
University of Colorado at Boulder

An efficient, cost-effective custodial operation can't be had without two things: custodial standards or contracts -- detail sheets that describe what, how frequently, and where various custodial tasks are to be done -- and a method of work assignment that provides enough labor to get the job done and not a bit more.

Standards And Contracts: Why They Are Often Useless

Most custodial standards and contracts bear a fatal resemblance to bio-rhythm charts. They may optimistically state, for example, that in this or that building floors will be swept every night and mopped once a week; that desks will be dusted every other night and bookshelves every two weeks; that light fixtures will be cleaned every three weeks and windows washed every two months; and that tile floors will be stripped and waxed every three months, and carpeting shampooed every six months, etc. Trouble is, if such a schedule could be followed -- and that "if" is a giant IF -- a chart of its rhythms would assume the curve of a surging wave that would, as regular as clockwork, crash down upon the heads of your custodians. And between the waves -- those periods when everything locks into phase and must be done simultaneously -- would be hollows with relatively little happening.

But in fact the custodians who must carry out this program are seldom given much information about it and so couldn't follow its variable dictates even if they wished. The upshot is that while managers create standards and contracts no one can follow, custodians improvise programs all their own. Under such a system good custodians are good, bad custodians are bad, most operations are rife with both extremes, and management is superfluous.

Work Assignment Methods: Near- or Far-Sighted, We've Still Got Trouble With Our Eyes

Our industry is not much better off when it comes to work-assignment methods, of which there are two main kinds:

The detailed method. Just count all the ashtrays in a building and multiply by five seconds; then measure all the tiled floors that get heavy traffic and multiply by one minute per ten square feet; then measure every other item and object and multiply it or them by so many seconds and so many minutes. After you've counted, measured, tabulated, multiplied, and itemized everything in the building, and then all the buildings -- a process that usually takes no longer than the construction of an Egyptian pyramid -- sum up all the seconds and minutes and hours. Then divide that sum by a working day or week and the result is how many custodians you need. But caution: if you're following the bio-rhythm standard or contract described above on some days you'll need only one and a half custodians, on others you'll need eleven. Oh well, nothing's perfect.

The general method. This is simpler. Divide the square feet to be cleaned by 18,000 or 22,000 or whatever number of square feet you decide is reasonable and that's how many custodians you need. Problem is that not all buildings are alike. A bank lobby is not a hospital ward, nor does a cafeteria have much in common with a basketball court, although each may have space needs identical to the next. So while the general method may be relatively accurate for telling you the total number of custodians you need, when it comes to assigning specific custodians to specific buildings it runs a close second to spinning a bottle or counting your toes.

A New Plan and How It Has Fared

At the University of Colorado a few years ago I proposed a new system of custodial management to Paul Morris, at that time Manager of Maintenance and Operations. Paul, who is now Director of Facilities Management Department, not only supported the new plan but insisted we proceed to put it into effect at full speed. The results pleased us very much. Among them:

1. A 25 percent cut in custodial staff to date while at the same time the square footage we clean increased 23 percent.

2. The almost total disappearance of patron and building user complaints. By "almost" I mean that it's a rare month that finds a single complaint called in.

3. Improved performance in every category in every year for the last five years. Currently the average custodian cleans 32,600 square feet. We expect this to increase again next year.

What follows is a brief description of our custodial management program, called the Six-Two Plan.

The Six and Two of the Six-Two Plan

The division of the working day. All custodial activities are divided into two categories: those which are to be performed as part of a daily routine and are therefore called "routine cleaning," and those that are to be performed on a recurrent basis, as assigned by a supervisor, and are therefore called "rotational cleaning."

The six hour routine. Six hours are provided for the "routine cleaning" by which we mean the minimum acceptable number of custodial acts to be performed every day in the sum of the units that comprise a custodial area. The "Standard for Routine Cleaning" (Figure A) lists the minimum standard for classrooms, labs, hallways, offices, stairs, and restrooms. At CU all custodians and supervisors are trained to this standard and carry a copy along during their working routine. Additional standards have been created in areas that diverge from the normal, as for example in gymnasiums, ice rinks, and locker rooms.

Please note that the Routine Standard does not deal in confusing time intervals--the custodian does everything on it every day without fail. I might add that an inspection sheet (Figure B) exactly conforms to the "Standard for Routine Cleaning." Note, too, that the inspection sheet does not deal in value judgements: if a thing is done correctly it is done well and if it is not done correctly we have failed. We do not say, in other words, that a trash can has been emptied "fairly well," or "not so well" or "poorly."

The two hour rotational. At some time during each working day two hours are set aside for rotational cleaning, by which we mean the assigned performance of the maximum number of custodial acts that can be accomplished in a given unit of a custodial area on a single day. I will come back to the notion of a custodial unit in a moment but for now I should add that at CU the average custodial unit consists of twenty-five to thirty units. Therefore while each custodial area receives a routine cleaning every day, at the end of every twenty-five or so working days it receives in addition an entire top-to-bottom deep cleaning.

We have of course provided each custodian and supervisor with a copy of our "Standard for Rotational Cleaning" (see Figure C) which we also call the Rotational Standard. You may observe that the Rotational Standard is necessarily more open-ended and less dogmatic than the Routine Standard. Here the supervisor is expected to determine exactly how many custodial tasks should and can be performed during that day's assignment.

The Custodial Area And Work Assignment

The area unit. The heart of the Six-Two Plan is in its method of breaking custodial areas into units and in coming up with a simple notation system for recording what, where, and when everything we do takes place. As I said earlier, at CU the average custodial area consists of a minimum of twenty-five units. The definition of a unit is available in a handout entitled "Establishing Custodial Areas" (see Figure D) that we provide for all our supervisors. I might point out that although we describe the unit in terms of space we are actually describing equivalents in time, each unit requiring as much time to clean as the next. A typical area by this method might consist of forty-two offices, two large labs, four medium-sized classrooms, a public corridor on each of two floors, four public restrooms, and four flights of stairs. That's twenty-four units, more or less.

The procedure for booking areas. When we began the process of "booking" custodial areas at CU a few years ago, I did the first few and handed the completed supervisors' books to their respective supervisors. But after that I held a class for an hour or so each evening for a week with the remaining supervisors. Each was provided with a blank "Schedule for Rotational Cleaning" (Figure E) and we simply walked through a few buildings, each of us making notes and returning to the classroom to compare results. At the end of the week although no two supervisors made exactly identical breakdowns, all were within acceptable range of one another and that's what we were after -- consistency. The supervisors were then sent out to book the areas in their own buildings, a process that involved no more than a brief walk-through the buildings with a quick look at each office and a notation in the Schedule. Most supervisors were able to complete this in their spare time in one or two weeks. (Incidentally, there was a considerable transfer of space as we discovered that some custodians were grossly overburdened and others much underused. Not infrequently a supervisor discovered that he could not justify the number of people assigned to him, in which case the extra people were either transferred to more hard pressed areas or allowed to lapse through attrition.)

I reviewed the results but basically, unless there was a particular problem or question, the supervisors were on their own. At CU we were firmly convinced that no plan would work that did not involve the supervisors from the ground up, and so they themselves created the programs for which they would thereafter be responsible. In other words, we gave the ball to the people in the field because they would have to play the game, not us.

How The Supervisor Uses The Six-Two Plan

Every custodial supervisor is responsible for a cluster of buildings: the average cluster has ten to twelve custodians. Each supervisor is provided with a three ring notebook with enough dividers to provide a section for himself and each custodial area under his direction.

The custodial sections. Each section contains a breakdown of the units in that particular custodian's area (refer again to Figure E, the Schedule For Rotational Cleaning) and a "Weekly Assignment Sheet" (Figure F). The assignment sheet contains space for each day's date and for the room numbers where rotational cleaning is assigned on that day. Immediately below are the words "Yes" or "No" one of which is circled to indicate whether or not the assignment is accomplished satisfactorily.

The supervisor's routine. The Supervisor begins each shift with a visit to every custodian under his direction. On this first visit the supervisor informs the custodians of rotational cleaning assignments to be performed that day. The assignments are selected from the Schedule of Rotational Cleaning -- in order, unless the supervisor has reason to skip ahead or backwards.

Each day thereafter the supervisor begins the shift be evaluating the rotational cleaning performed the previous day, circling the "Yes" in the appropriate space on the Weekly Assignment Sheet if the assignment was completed satisfactorily, the "No" if it was not. If the assignment was completed satisfactorily the supervisor puts the completion date in the appropriate box on the Schedule of Rotational Cleaning and makes the next assignment. The evaluation process takes place in the company of the custodian, whenever possible. Notice that a complete history of the custodial area is being recorded and yet the supervisor never has to do more than: write a number, circle a word, and enter a date. For a look at a working Schedule of Rotational Assignments see Figure G which is discussed further under the "Visualizing custodial performance..." section under the sub-head Managing By The Six-Two Plan: Some Benefits And Possibilities.

Managing By The Six-Two Plan: Some Benefits And Possibilities

It isn't possible to cover all the potential of the Six-Two Plan in this relatively short session. However I would like to end with several statements on the additional benefits and possibilities the plan offers.

Floorwork. Custodians love to wax floors. Left to their own they will wax floors in preference to almost any other task (i.e. cleaning around the bases of toilets). They will often rewax floors in favored rooms even though those floors don't need it. The result of this joy in waxing is that expensive labor and materials are wasted. For this reason we added a "Schedule for Floorwork" for each custodial area in our supervisors' binders. It works exactly like the "Schedule for Rotational Cleaning" (Figure E) except that you can now set the ratio of time spent on floors to the time spent on less expensive straight cleaning, which is woefully neglected in many institutions. You might determine that you want no more than one in five assignments to be floorwork, for example. Or you might set a general policy with variations in this or that isolated building. The important point is that you control it.

Staging cutbacks in expenses. The Six-Two Plan offers a variety of options for either temporary or permanent cutback in custodial budgets. I'll list only a few but notice that it's possible to determine the exact level of cutback and the exact effect.

1. Eliminate floorwork for a time and realize a one or two percent savings. This is a modest but effective method for curtailing materials overruns -- and remember, you've already set the ratio so you know exactly how much you can save.

2. For a 6 percent annual savings educational institutions might consider running nine months of the year with full employment but dropping to 75 percent of full employment with the summer quarter. Make 25 percent of your total labor force temporary or seasonal appointments that automatically lapse. The remaining 75 percent would expand to fill the gap using the plan outlined below but on a seasonal basis only.

3. For a 25 percent savings eliminate rotational assignments. In the long run your institution will suffer increased maintenance expenses, but in the short run you can cut this much with no effect whatsoever on routine cleaning. Simply expand the six-hour routine of the Six-Two Plan to an eight-hour routine, which means each custodian assumes an additional eight to ten units of cleaning in his area in place of the former two hours of rotational assignment.

Visualizing custodial performance anywhere from your deskside. A glance at any Schedule for Rotational Cleaning (Figure G) tells us several things immediately: the latest date any room was thoroughly cleaned, the time elapsed between cleanings and -- most important of all -- whether the supervisor is accomplishing cleaning in a timely and consistent manner throughout the area, or letting some things slide while others consume the lion's share of his effort. All this, I repeat, can be established at a glance.

Rating performance. At CU we regularly grade supervisory performance by the following criteria: What are the number of rotational assignments a supervisor should achieve in a given month after adjusting for absences and vacation days? And what are the number actually achieved? Suppose he actually achieved 90 when 100 were possible: his score is 90 percent. For reasons too mysterious to explore here it is rare for supervisors to score 100 percent, but our best consistently score in the 90s, while our worst began in the 50s. We've declared 75 percent the minimum acceptable score and it's amazing how easy this made it to identify supervisors who had problems (without so much as taking a step outside our office). In turn the data entered in their own binders made it simple to review what those problems were and to correct them.

Verification of performance. There is no way to cheat on the Six-Two Plan. Our managers conduct regular spot-checks of the rotational assignments entered in the binders by the supervisors. If the supervisor in building A says custodians a, b, and c gave acceptable rotational cleanings to rooms one, two, and three, the manager can go straight to those rooms and verify or dispute the claim. These checks, performed randomly, make dishonesty hazardous. Also pointless, for there is no good reason for a supervisor to cheat in the first place: provided he hands out the assignments the Six-Two Plan makes it so easy for him to control, it is not his fault if the custodian doesn't accomplish the assignment. Moreover, we freely claim the fault ourselves if we don't give the supervisor an effective custodian, or make effective an ineffective custodian.

Training. We instituted a five-day training program for all custodians when we initiated the Six-Two Plan at CU. The main feature of the Training Program is to make sure each applicant learns exactly what our minimal standard of performance is, and that the standard is achieved within specified time limits. If at the end of one week a custodial trainee cannot accomplish these objectives -- and after all, graduation will mean cleaning 25 units in six hours, which is the point of all this -- he or she is not continued into a permanent position. We believe this Training Program is the key and single most important contributor to the success of the Six-Two Plan.

Computerization. I would like to emphasize that every phase of the Six-Two Plan adapts to computerization and computer monitoring. How it adapts depends on two things: the kind of computer or computer program available and your freedom to adjust time sheets (or some variant thereof).

Conclusion

By this time I have probably exhausted your attention and patience but I'm a long way from exhausting the Six-Two Plan, or even scratching its surface. If you are interested and have questions or comments, please feel free to write or telephone for additional information. I am at your service. Thank you.

FIGURE Ⓐ

STANDARDS FOR ROUTINE CLEANING

I. The Cart

Every trash cart must have a caddy and the following basic supplies (more are allowed but not less):

1. Dust pan
2. Dust pan brush
3. Supply of trash can liners
4. Supply of paper towels
5. Can of Ajax
6. Spray bottle of glass cleaner
7. Spray bottle of disinfectant
8. Clean dust rag
9. Putty knife
10. Bad order book, reminder forms, pad and pen.

ALL CUSTODIANS ARE RESPONSIBLE FOR PERFORMING THE FOLLOWING TASKS ON A DAILY BASIS IN THEIR ASSIGNED AREAS;

II. Routine Cleaning of Offices

1. Telephone wiped with clean dusting cloth.
2. Ash trays emptied and wiped clean with damp paper towel.
3. Trash cans emptied and re-lined if necessary.
4. Floors swept or vacuumed.
5. Chairs and furniture replaced in neat order.

III. Routine Cleaning of Classrooms and Labs

1. Desks and chairs arranged in diagrammatical order.
2. Trash picked from floor and desks.
3. Trash cans emptied and relined if necessary.
4. Telephone wiped with clean dusting cloth.
5. Ash trays emptied and wiped clean with damp paper towel.
6. Floor swept in aisles and under desks and chairs.
7. Blackboards and chalktrays washed.
8. Chalktrays supplied with chalk.

IV. Routine Cleaning of Hallways and Stairs

1. Trash cans emptied and relined if necessary.
2. Floor swept or vacuumed (and mopped if necessary).
3. Stairs swept or vacuumed (and mopped if necessary).
4. Drinking Fountains washed.
5. Remove posted materials from all locations except approved bulletin boards.
6. Interior glass and door windows washed as necessary.

V. Routine Cleaning of Bathrooms

1. Spray with disinfectant and wipe clean with paper towel:
    a. Tops and undersides of toilet seats
    b. Toilet rims and outer perimeter of toilet bowls..
    c. Rims and outer surfaces of urinals.
    d. Chrome fixtures of toilets, urinals and sinks.

2. Swab inside of toilet bowls and urinals with disinfectant.
3. Clean entire surface of sinks with appropriate cleanser.
4. Wash mirrors with glass cleaner and paper towel,
5. Dush shelves and/or ledges and towel dispensers.
6. Empty trash cans and reline if necessary,
7. Resupply dispensers and soap trays.
8. Sweep and damp-mop floors with disinfectant solution.

VI. Routine Cleaning of Custodial Station

1. Clean and prepare custodial equipment for the next day's work.

FIGURE Ⓑ

INSPECTION OF ROUTINE CLEANING
INSPECCION DE LIMPIEZA DIARIA

DATE/*FECHA*: ____________________

TIME/*HORA*: ______________ ____

SUPERVISOR: ____________________

SCORE: ____________________________

BUILDING/*EDIFICIO*: ________________

AREA: ________ __________________

One point is scored for each completed item. _____ is the possible score. _____ and below indicates a need for retraining.
Un punto és marcado para cada articulo completado. _____ es el posible score. _____ y abajo indica una necesidad para entrenamiento.

I. Trash Cart and Caddy/*Carro de basura y bastidor*

___Dust pan/*Pala de recoger la basura*
___Dust pan brush/*Cepillo*
___Trash can liners/*Bolsas para la basura*
___Paper towels/*Toallas de papel*
___Putty knife/*Cuchillo raspador*
___Ajax
___Glass cleaner/*Limpiador de vidrio*
___Forms/*Formas*
___Disenfectant/*Desinfectante*
___Clean rag/*Una garra limpia*

II. Offices/*Oficinas*

___Telephone dusted/*El telefono desempolvado*
___Ash trays/*Ceniceros*
___Trash cans/*Botes de basura*
___Floors/*Pisos*
___Order/*Orden*

Comment/*Comentario*: ____
____

III. Classrooms and Labs/*Salones de clase y laboratorios*

___Telephone dusted/*El telefono desempolvado*
___Ash trays/*Ceniceros*
___Floors picked up/*Los pisos recogidos*
___Floors swept/*Los pisos barridos*
___Trash cans/*Botes de basura*
___Blackboards/*Pizarrones*
___Order/*Orden*
___Chalk supply/*Proveerse de gis*

Comment/*Comentario*: ____
____

INSPECTION OF ROUTINE CLEANING
INSPECCION DE LIMPIEZA DIARIO

IV. Hallways and Stairs/*Corredores y Escalones*

___Drinking fountain/*Fuente de tomar agua*
___Floors swept/*Los pisos barridos*
___Stairs swept/*Los escalones barridos*

___Trash cans/*Botes de basura*
___Bulletin board/*Tablero de boletin*
___Interior windows/*Ventanas interiores*

Comment/*Comentario*: ____________________

____

V. Bathrooms/*Baños*

___Toilet seats/*Asientos del inodoro*
___Toilet rims/*Bordes del inodoro*
___Urinal rims/*Bordes del urinario*
___Fixtures/*Instalaciones*
___Trash cans/*Botes de basura*
___Floors/*Pisos*

___Bowls & Urinals disenfected/*Adentro de los inordoros y urinarios desinfectados*
___Sinks/*Lavabos*
___Mirrors/*Espejos*
___Dusting/*Desempolvar*
___Supplies/*Materiales*

Comment/*Comentario*: ____________________

____

VI. Custodial Station/*Estacion del Custodian*

___Custodial Equipment/*Equipo de Custodial*

FIGURE Ⓒ

STANDARDS FOR ROTATIONAL CLEANING

Each custodial area has been divided into a sequence of rooms on the supervisor's "Schedule For Rotational Cleaning." As the supervisor assigns specific rooms to his custodians for rotational cleaning he, the supervisor, must determine exactly what he expects his custodian to accomplish in the allotted time span. Bear in mind that rotational cleaning is strictly additional to the cleaning described in the "Standard For Routine Cleaning." Areas for the supervisors consideration would include:

1. All corners and difficult-to-reach areas should be swept out or vacuumed
2. Bookshelves, coat racks, cabinets desk tops, picture frames, etc., should be thoroughly dusted and perhaps waxed, polished or treated.
3. Furniture should be dusted and upholstered furniture vacuumed - shampooed if necessary.
4. All window frames and ledges, and all ledges whatsoever (tops of blackboards, floorboards, door frames, molding, etc.), should be washed with damp sponge in addition to dusting.
5. Light fixtures should be dusted and cleaned.
6. Doorframes, doors, and lower wall surfaces may require washing.
7. All corners and "seams" of the room should be swept free of cobwebs.
8. The telephone should be washed with a clean rag and disinfectant.
9. The floor may require mopping with a soap solution.
10. Bathroom walls and partitions washed with disinfectant.
11. Wash entire surface of toilet bowls, urinals and exposed plumbing and pipes.
12. Arrange and clean custodial closet.

Page 1 of 1

FIGURE Ⓓ

ESTABLISHING CUSTODIAL AREAS

I. The Size of a Custodial Area.

A custodial area consists of an average of twenty (20) units. (By average we mean that a normal custodial area may range from 18 to 25 units, but in general we try to stay as close to 20 as possible.

II. How the Units Are Cleaned.

The custodian is expected to complete the routine cleaning of these 20 units in six hours or less, and to return to a single unit to perform a "rotational cleaning" assignment (i.e. to perform as many of those cleaning tasks not listed in the "Standard for Routine Cleaning" as is possible) in the remaining two hours.

III. The Order of Cleaning.

The six hours of routine cleaning may be performed in a single block of time or may be broken into parts (three and three, or four and two, etc.). The two hours of rotational cleaning should usually take place after the routine cleaning is completed, but may be inserted at any point.

IV. Defining a Custodial Unit.

A unit may consist of:

A. Three (3) average offices, of one or two work stations each.

B. Two (2) medium-sized classrooms/labs/reception areas.

C. One (1) large classroom/lab/reception area.

D. Three (3) small bathrooms (or two medium-sized restrooms, or a single large restroom).

E. One or two stairways of a single flight each, plus a hallway or corridor, or a portion thereof.

F. Any area, of any size or make-up, which can be reasonably expected to receive a through "rotational cleaning" in two hours or less. For example, a large public corridor, all or a section of a gymnasium, or a section of open warehousing space.

FIGURE Ⓔ

SCHEDULE FOR ROTATIONAL CLEANING 1.00.00.1
PLAN PARA LIMPIEZA ROTATORIA

CLUSTER 4
BLDG (EDIFICIO) REGENT HALL

AREA #1
NAME

SEQUENCE OF ROOMS
SERIE DE CUARTOS

DATES COMPLETED

1	2	3	4	5	6	7	8	9	10	11	12
450 W. HALF	450 E. HALF	[illegible] 333 384	352 353 354	351 355	304 302 HALL H42	400 W. HALF	[illegible] E. HALF	[illegible] 334 335 ELEV.	301 302 [illegible] STAIRS [illegible]	201 202 203	204 [illegible] [illegible]

NOTE:

As each unit of rooms is cleaned the completion date is entered in the box beneath the unit, and in the box beneath that on the next cleaning, etc.

DATES COMPLETED

13	14	15	16	17	18	19	20	21	22	23	24

Page ________ of ________

FIGURE Ⓕ

1.002.02

WEEKLY ASSIGNMENT SHEET
HOJA DE ASIGNAMIENTOS SEMANALES

Cluster (Grupo)____________________ Area______________________

Building (Edificio)____________________ Name_________________________
(last) (initials)

1. Day and Date Assignment
Dia y Fecha___________________________Asignacion_____________________________

Accomplished satisfactorily Yes No If no, explain and reschedule:
Consumado satisfactorio Si No Si no, explique (y plane de vuelta):

____

2. Day and Date Assignment
Dia y Fecha___________________________Asignacion_____________________________

Accomplished satisfactorily Yes No If no, explain and reschedule:
Consumado satisfactorio Si No Si no, explique (y plane de vuelta):

____

3. Day and Date Assignment
Dia y Fecha___________________________Asignacion_____________________________

Accomplished satisfactorily Yes No If no, explain and reschedule:
Consumado satisfactorio Si No Si no, explique (y plane de vuelta):

____

4. Day and Date Assignment
Dia y Fecha___________________________Asignacion_____________________________

Accomplished satisfactorily Yes No If no, explain and reschedule:
Consumado satisfactorio Si No Si no, explique (y plane de vuelta):

____

5. Day and Date Assignment
Dia y Fecha___________________________Asignacion_____________________________

Accomplished satisfactorily Yes No If no, explain and reschedule:
Consumado satisfactorio Si No Si no, explique (y plane de vuelta):

____

SCHEDULE FOR ROTATIONAL CLEANING
PLAN PARA LIMPIEZA ROTATORIA

1.00.00.1

FIGURE (G)

CLUSTER SEVEN

BLDG (EDIFICIO) MCDB 0c, 0e & 00/E-Wing 00

AREA #8

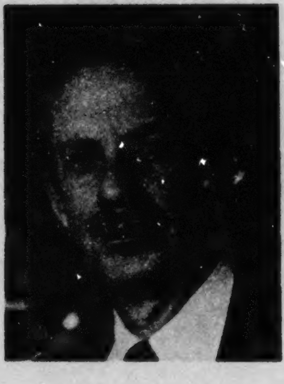
NAME

SEQUENCE OF ROOMS
SERIE DE CUARTOS

1	2	3	4	5	6	7	8	9	10	11	12
B034 Foyer Lobby	B035 Rest Rooms B036	B041 B043 B043A	B047 B047A B049A B049C	B049 B051	B053 B059 B059A	B060 Loading DOck 0 lvl Hall east	B058 (east) B058C B058D B058E B058F	B058 (cen.)	B058 (west) B058A B058B	B0036 B0036A Rest Rooms	B0040 B0042 B0046
1/4/83	1/6/83	1/17/83	1/19/83	1/20/83	1/24/83	1/25/83	1/26/83	1/27/83	1/28/83	2/1/83	2/9/83
4/20/83	3/10/83	3/18/83	3/22/83	3/28/83	4/4/83	4/6/83	3/29/83	3/30/83	3/31/83	4/8/83	4/22/83
5/4/83	4/21/83										
	5/6/83										

SEQUENCE OF ROOMS
SERIE DE CUARTOS

13	14	15	16	17	18	19	20	21	22	23	24
B0050 B0050A B0058 B0059	B0055 00 lvl Hall east	B0021 B0011	B0020 B0020A	E0041 E0039 E-Wng Hall	E0014 (A-C)	E0022 E0040	E0046	B0024 B0026	B0032 Elev. Cent. Hall	00 lvl Hall west	MCDB East Strs. 4-00
2/10/83	2/11/83	2/14/83	2/16/83	2/17/83	2/21/83	2/28/83	3/2/83	2/11/83	3/8/83	3/14/83	2/23/83
X	6/13/83	5/27/83		3/8/83							4/7/83
				3/10/83							4/18/83



Living with the Customer: Building a Comprehensive Program for Physical Plant Communication

by William D. Middleton, P.E.
University of Virginia

Introduction

Any discussion of the management problems of large organizations sooner or later gets around to the topic of communications. Effective communication with or within large organizations is inherently difficult; the bigger the organization, the more difficult the problem.

This is a particularly appropriate topic for physical plant administrators, for communication is inherently more difficult for us than it is for almost any other component of a college or university. We do more, and more diverse, things than just about anyone else, and what we do can affect everyone within the institution. Thus, we probably have more things to communicate about and more people to communicate with than anyone else in our institutions.

I would maintain that an effective communication program is an essential element of a successful physical plant organization. A good communication program won't help you much if your organization is ineffective, but you can't be truly effective in the physical plant business without one.

Organizing for Communication

In organizing a program for better communication, there are several basics that we first need to consider:

Why do we communicate?

- First and foremost, we need to tell people how to do business with physical plant.
- We need to provide information about physical plant activities of specific interest to someone.
- We need to get information out about physical plant activities of a general interest or impact within our institutions.
- We need to develop a general awareness of the nature and scope of physical plant operations and accomplishments.

- Finally, a very important communication need is to get feedback concerning the quality and responsiveness of physical plant services.

Who do we need to communicate with? (And who needs to communicate with us?)

- Administrators who work with physical plant on a regular, continuing basis. Because they work with us regularly, these people are usually fairly easy to reach.

- Faculty members, researchers, medical staff and the like who have only an occasional need for specific physical plant services. This group is much more difficult to reach.

- The university community at large. Most of these people never need physical plant support, at least on a direct basis.

- Your own physical plant staff.

Each of these groups is best reached in different ways.

A Communication Philosophy

A successful communication program must reflect a true service-oriented organizational philosophy. The organization has to sincerely want to be responsive, to be willing to change and improve its operations, and to be willing to admit error. If the organization's attitude--and this is all too common in service organizations--is "that's the way it is," "if it's wrong, it must be the customer's fault," and the like, there isn't much point in worrying about communications.

People need and want to know what's happening, and they need to feel that there is a way to be heard--that their problem will get a fair hearing and that they will get real answers to their questions.

How to Communicate?

The diverse nature of the things we must communicate about and the diverse nature of the people we must communicate with mean that there can be no single channel of communication, or even just a few, that will adequately meet our communication needs. An effective program must employ a multiplicity of ways and means to build effective two-way communication.

The substance of my discussion today is to describe the comprehensive program we have developed at the University of Virginia to try to meet this need.

University of Virginia, Physical Plant Communication

We have developed several important publications as a part of our communication program:

- Physical Plant Services Guide. A services guide is the most important single item in our entire communication program. It is our catalog of what we do, who does it, and how to get it.

  In developing our Guide, we looked at many such guides developed by other institutions. A number of them were extremely well done, but others were hastily prepared, poorly organized and written, and therefore nowhere near as effective as they should be. We put forth a great deal of effort to try to avoid this.

  We began with our own ideas of what content the Services Guide should have, and then formed an informal "panel of users" and asked for their ideas. We then had them review what we had written after we completed a first draft of the guide. After we had completed the writing, we asked the editor of our university publications to edit the material to be sure that it was both readable and easily understandable to non-physical plant readers. Finally, when we were ready to publish we hired a professional graphics designer and got a professional production job to be sure that we had the kind of professional publication we wanted.

  Our Services Guide covers such items as policy, services available, our priority system, and financial concerns; it summarizes the capabilities and services available in each of our major functional areas, such as facilities planning and design, maintenance, repair, and renovation, and utilities services; and departmental organization and functions. A very successful feature of the Guide is an alphabetical quick-reference guide to physical plant services. We also included in an appendix samples of forms and reports, and provided a directory of all key departmental personnel.

  The Guide was widely publicized and distributed throughout the University. We plan to revise and reissue it on either an annual or semi-annual basis.

- Physical Plant Services Bulletins. We supplement our Services Guide with a publication of Services Bulletins which provide "short-range" information, such as announcement of new services or service changes, seasonal service notices, or our annual rate schedule. By intent, our Services Bulletin is not on a fixed schedule, but is published only as needed. As with the Guide, we made a special effort to develop an attractive graphic design, and each Bulletin is prepunched for loose-leaf notebook to encourage retention in an organized fashion. Periodically, we issue an index of all Bulletins that are still effective.

- Project Status Reports. We have developed a microprocessor-based reporting system which generates monthly project status reports to key persons interested in each project. We have two types of reports: one for our major capital projects and another for all other smaller projects. These reports summarize the current status of each project and compare actual progress against the plan for the project. An important item of information on each report is the name and telephone number of the project manager or other responsible manager.

- Annual Report. We are required to submit an annual report of operations to our responsible vice president and the president, but we go far beyond this basic requirement to make the annual report a comprehensive review of each year's operations and achievements, and a summary of our plans and objectives for the coming year. We make it an attractive and professional publication, and distribute it widely within the university as a means of building awareness of what is going on in physical plant.

- University Publications. We regularly use the university-wide publications prepared by the university's information organization whenever there are appropriate news items and stories from physical plant of general university interest.

Organizational Procedures

- Facilities Representatives. We ask each university department to appoint a facilities representative who acts as a continuing central point of contact for that department with the physical plant organization. We meet periodically with these representatives and keep them as well informed as we can. This has been an effective way to improve the day-to-day relationship between physical plant and individual university departments.

- Staff Engineers. We have appointed two of what we call staff engineers: one in the university medical center and one responsible for all of the remainder of the university. These are senior, professional level managers who act as a sort of "customer service representative." The staff engineers are responsible for providing advice and assistance concerning any kind of physical plant services and for coordinating and resolving any kind of physical plant problem. We publicize the availability of the staff engineers as widely as we can, and try to make them a very "high profile" position. We continue to encourage people to get in touch with the specific person who is responsible for a particular service or project, but the staff engineer is someone who can always help if they don't know who else to call.

- Project Managers. For all major facilities projects and every priority project in our system, we appoint a project manager who is responsible for "cradle to grave" project management, coordination, and customer liaison concerning the project. Most of our project managers are from our architectural and engineering services division, since design is usually involved; but sometimes they are appointed from elsewhere in the department.

- Physical Plant Advisory Board. We set up an advisory board last year and invited each vice president to nominate appropriate members. The board's membership, therefore, represents a very broad cross section of the university's faculty and staff. The board meets every two to three months, with a chairman elected from the membership, and the board sets its own agenda. We found that it works extremely well as a two-way communication channel for the department; for example, when we recently set out to establish new departmental objectives for 1983-1984, the advisory board developed for us a number of good, solid items that have been incorporated into our objectives.

Other Procedures

- Seek Communication Opportunities. In order to learn as much as I can about the general perception of physical plant support services, I meet periodically with deans, department heads, and other key administrators to discuss their needs and problems. I seek opportunities whenever possible to attend such events as deans' meetings, research faculty gatherings, and the like, both to learn what problems they are encountering and to tell those groups what we are doing in physical plant. When appropriate, we occasionally set up special meetings to present information to the university community. A recent example was a special program that we put on to present details of our newly-developed six-year Capital Budget construction program.

- Build an Informal Network. I attend as many of the university's social and official functions as I can. The most important reason is that I enjoy them, but an important secondary benefit is that these events provide excellent opportunities to become widely acquainted with university faculty and staff on an informal basis. These informal contacts provide still another valuable channel of communication for the department.

- Be Responsive. Our communications are not effective if we are not responsive to the problems and questions that are presented to us. I consider it essential that I return all telephone calls promptly, answer my mail, or just get out of the office and go see someone with a serious problem with physical plant, and I encourage our other key managers to go out and do likewise.

- Departmental Image. The way people view us is an important part of what we communicate, and I think it is important that our physical plant organizations convey an image of the competent, professional organization that we know they are. We have tried to do this in many ways. Some of the most important include our emphasis upon making every publication from the department a thoroughly professional effort; we emphasize keeping our vehicles in good repair and clean, and have developed a professional-looking marking system; we have given a lot of attention to the appearance of the uniforms we provide our blue-collar employees; and we publicize as widely as we can the professional and technical achievements of the physical plant staff.

Internal Communication

If you expect your people to convey the attitudes and the approach that you want for physical plant, you have to tell them what these are; a good program of internal communication within physical plant is just as necessary as your program for external communication. Some of the things that we use include a bimonthly physical plant newsletter that is distributed to our entire staff, and we send our managers and supervisors copies of everything that we send outside the department. I make a point of meeting periodically with the department's managers and supervisors in small groups that extend down to our first-line supervisors to discuss current developments in the department and to respond to their questions and comments. We make a special effort to recognize achievements of each member of the department.

Conclusion

I wish I could say to you, do all these things and your communication problems will be over. I'm afraid that it's not quite that easy.

A few weeks ago as I was organizing my notes for this discussion, I was feeling pretty good about all the great things we've been doing until I attended a meeting of our research faculty forum. A faculty acquaintance there conceded that some things had gotten better in physical plant, but then observed: "the biggest problem we have with your organization is communication." Worse yet, he illustrated his remarks with some good examples showing how far we still had to go.

That may be a poor note upon which to end, but I think it makes a very important point, and that is simply that attainment of perfect communications is something which we can work toward but we will probably never arrive there. Working toward more effective communications has to be a continuous process which becomes an integral, conscious part of our daily activities as physical plant managers.

Exhibitors

ACE/APPA/NACUBO Energy Task Force
Washington, D.C.
Christopher Crittenden, Director

Advanced Automation Concepts, Inc.
Marietta, Georgia
Robert M. Pap, President

Affiliated Roofers, Inc.
Golden, Colorado
Lowell R. Hutson, President

American Air Filter
Louisville, Kentucky
Gary Heilmann, Marketing and Communications Manager

American Building Maintenance
San Francisco, California
Thomas W. Smith, Vice President for Colleges and Universities

American School & University
Philadelphia, Pennsylvania
Michael E. Spring, Assistant Vice President, Marketing and Sales Promotion

ARA Environmental Service
Philadelphia, Pennsylvania
Bill Church

APPA Information Center
Washington, D.C.
Teresa Burnau Evans, Director of Special Projects

Applied Management Engineering
Virginia Beach, Virginia
Jack S. Galvin, Administrative Director

Armor Elevator Co., Inc.
Louisville, Kentucky
Marjorie Floyd, Manager, Marketing Services

Best Lock Corporation
Indianapolis, Indiana
Greg Candler, Advertising Director

Building Monitoring Systems, Inc.
New York, New York
Jeffrey Abramsky, National Sales Manager

Building Operating Management
Milwaukee, Wisconsin
Robert Wisniewski, District Manager

Building Systems Company
Farmington, Connecticut
Edythe Brewster

Carpenter Insulation & Coatings Company
Dallas, Texas
Wayne P. Gray, Manager, Insulation & Coating

Carlisle SynTec Systems
Carlisle, Pennsylvania
Kem Scott, Director of Marketing and Customer Services

Carrier Air Conditioning
Syracuse, New York
David Lind

Ceramic Cooling Tower Company
Fort Worth, Texas
Lee Newman, Manager, Advertising

Coil Company, Inc.
Colwyn, Pennsylvania
Peggy Schnepp, Advertising and
Promotions Manager

Crothall Systems, Inc.
Newark, Delaware
James P. McNally, President

Daniels Associates, Inc.
Addison, Illinois
Daniel Bomberg, Vice President

Decogard Products
Muncy, Pennsylvania
Richard W. Langer, Regional Sales
Manager

Dectron Inc.
Montreal, Quebec, Canada
Armin Kunert, President

DeVac, Inc.
Minneapolis, Minnesota
Rodger Bartlett, Vice President
Business Development

Donohue & Associates
Waukesha, Wisconsin
David W. Baraniak, Regional Marketing
Manager

Dover Corporation/Elevator Division
Memphis, Tennessee
Charlene Leffler, Contract Services
Manager

Durex
Louisville, Kentucky
Gary Lawrence, Sales Manager

Ebco Manufacturing Company
Columbus, Ohio
Steve Clegg, Sales Promotion Manager

Eckel Industries
Cambridge, Massachusetts
John W. Flood, Vice President

Electronic Systems USA, Inc.
Louisville, Kentucky
Darrell Newton, President

Energy User News
New York, New York
Jim Chapman, Publisher

Engineering Measurements Company
Longmont, Colorado
James C. Roby, Manager, Marketing
Flow Products

Frederick Enterprises, Inc.
New Albany, Indiana
Larry Barker, Director of Marketing

Futura Coatings, Inc.
Hazelwood, Missouri
Jerry Schenke, Vice President--Marketing

Greater Columbus Convention & Visitors Bureau
Columbus, Ohio
Linda Williams Martin, Vice President,
Marketing

Harco Corporation
Medina, Ohio
Joan L. Mascio, Exhibits Coordinator

Heath Consultants, Inc.
Stoughton, Massachusetts
Linda Bowman, Convention Coordinator

Heat Timer Corporation
Fairfield, New Jersey
Michael Pitonyak, Chairman

High Voltage Maintenance Corporation
Dayton, Ohio
Robert Chelle, President

Hillyard Chemical Company
St. Joseph, Missouri
Clark Hampton

Honeywell Braukmann
Batavia, New York
Whit Thompson, Sales Manager

Honeywell Inc.
Minneapolis, Minnesota
Denny Lynard, Marketing Communications

Host-Racine Industries, Inc.
Racine, Wisconsin
Lisa M. Arents-Koenen, Trade Show Manager

Hutton Publishing Company
Jericho, New York
Harley Macomber, President

Intertech Remote Sensing Ltd.
Ottawa, Ontario, Canada
Hugh W. MacKay, Project Manager

Johnson Controls, Inc.
Milwaukee, Wisconsin
Ben Gultch, Exhibit Coordinator

Johnson Energy Systems
Milwaukee, Wisconsin
Jim Norgart, Marketing

Kalamazoo Manufacturing Company
Kalamazoo, Michigan
Bob DePierre, Vice President--Sales

Kearney Division of Kearney-National, Inc.
Atlanta, Georgia
Dan Buehl, Manager-Technical Communications

Kenall Manufacturing Company
Chicago, Illinois
Vicky Newell, Advertising Manager

Lawrence Locksmith Supply Corp.
Oceanside, New York
Jon Walker, Institution Sales Manager

LCN Closers
Princeton, Illinois
Robert G. Hatfield

Macon Control Corporation
Riverside, Michigan
Nick Rose III, General Manager

Miracle Recreation Equipment Co.
Grinnell, Iowa
W. B. Sleeuwenhoek, Vice President--Sales

The Mogul Corporation
Arlington, Texas
James M. Payne, Project Manager

Multi-Contract USA
Petaluma, California
Robert S. Deal, President

Nalco Chemical Company
Oak Brook, Illinois
Diane L. Hamburger, Director--Marketing Communications

Novitas, Inc.
Santa Monica, California
James Himonas, Jr., President

Otis Elevator
Farmington, Connecticut
David Hesford

Pacific Technology, Div. Butler
Manufacturing Co.
Kirkland, Washington
Norm Noble, Marketing Manager

Pedus Building Services
Los Angeles, California
Andre Nicassio, Vice President

Perma-Pipe
Niles, Illinois
Walter W. Nisbet, Vice President/
Director of Marketing and Sales

Pitzer Incorporated
Pittsburg, Kansas
George Pitzer, President

Planned Maintenance Systems
Arlington, Virginia
Charlie Gold

Postcraft Company
Tucson, Arizona
Kim M. Sweetman

Protexulate, Inc.
Ramsey, New Jersey
Sydnye Dufton, Vice President

Rotocast Plastic Products, Inc.
Miami, Florida
Martin Bernardi

Rovanco Corporation
Joliet, Illinois
Jack Curley, Director--Marketing Sales

Safety Technology Corporation
Dearborn, Michigan
John Taylor, President

Santana Products Company
Richmond, Virginia
Thomas M. Lynch

School Product News
Cleveland, Ohio
Ginger Koneval, National Sales Manager

Security Latch Co.
Plainwell, New Jersey
Bob Vanderboegh, President

Service Engineering Associates
Atlanta, Georgia
Edwin B. Feldman, President

Servidyne Inc.
Atlanta, Georgia
Joseph B. Middleton, Vice President

Stanley Magic Door
Farmington, Connecticut
Jeff Bye, Product Line Manager

Stiebel Eltron North America
Westwood, Massachusetts
J. Thomas Selldorff, President

Stranco
Bradley, Illinois
James M. Strand, Secretary-Treasurer

Systems Associates
Bowling Green, Ohio
J. David Codding, President

Thermal Pipe Systems, Inc.
Chester, Virginia
Walter T. Huber, Vice President

Time Energy Corporation
Houston, Texas
Marilu Rumfolo, Director--
Governmental Affairs

Tishman Research Company
New York, New York
Kurt Emmerich, Marketing Coordinator

TPC Training Systems
Barrington, Illinois
Lisa Yaney, Trade Show Coordinator

T&S Brass & Bronze Works, Inc.
Travelers Rest, South Carolina
Michael J. Magrino, Vice President--
Marketing

United Technologies Corporation
Hartford, Connecticut
Roger D. LaForte

Urethane Foam Contractors Association
Dayton, Ohio
Jane E. Treiber, Managing Director

Virco Manufacturing Company
Torrance, California
Lee Helgoe, Advertising Manager

VM Decal Corporation
Cleveland, Ohio
Diane B. Ewanko, Product Manager--
Signage

Von Duprin, Inc.
Indianapolis, Indiana
Charles Heckman, Sales Manager

Weathergard Roofing Systems, Inc.
Memphis, Tennessee
Herbert Garber, Director of Marketing

Wenger Corporation
Owatonna, Minnesota
Julie Jirele, Convention Coordinator

Western Waterproofing Company, Inc.
St. Louis, Missouri
Doyle Wilhite, Marketing Consultant

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Gene Reagan, Associate

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